Vol. XLIX

TABLE OF CONTENTS.

No. 11

(20 pages; no inset.)

Page

ENGINEERING NEWS OF THE WEEK 225

LEADING ARTICLES:

The Yazoo River Diversion Canal at Vicksburg, Miss. (illustrated) 226

The Cost of Pumping at the Short Mountain Colliery of the Lykens Valley Coal Co. R. V. Norris, M. Am. Inst. M. E. 228

A Comparison Between Eye-Bar Chains and Wire Cables for Suspension Bridges. Wilhelm Hildenbrand, M. Am. Soc. C. E. 229

Notes from the Engineering Schools 231

A 50,000-Volt Electric Power Transmission Line, 65 Miles Long 232

Laying 6-ft. Concrete-Jacketed Riveted Steel Pipes under the Hackensack and Passaic Rivers (illustrated) 232

A New "Automatic" Level Rod (illustrated 232

The Improvement of the Entrance to Cumberland Sound, Georgia and Florida (illustrated) ..... James H. Bacon, M. Am. Soc. C. E. 239

A Blast Furnace to Utilize Flue Dust 243

Report of Special Commission of Engineers on the Plans for the Manhattan Bridge, New York City 243

A Railway Trestle with Bents of Reinforced Concrete (illustrated) ..... Wm. A. Allen, Assoc. M. Am. Soc. C. E. 244

EDITORIAL COMMENT.—The New Bond Issue of the United States Steel Corporation—The Advantage of Letting Large Contracts in Sections—Plans for a New York Water Supply, from the Northern Lakes—The Designs for the Manhattan Suspension Bridge—Investigations of Water Waste and Leakage in Boston—The Development of Power from River Currents—Road Building by Indians 234

EDITORIAL.—The Carter Contracts in the Light of To-day 235

LETTERS TO THE EDITOR.—The Briquetting of Fuel: R. L. Gifford—Is Second-Foot a Proper Substitute for Feet per Second?: H. M. Wilson—Some Common Objections to the Use of Spiral Curves, in Railway Location: H. E. Abbott—Effect of Long Lines of Hose and Small Mains on Fire Streams: S. A. Charles—A Defence of Electric Iron Reduction: Keller, Leleux & Co.—Artificial Underground Water Supplies: J. W. Ledoux—The Utilization of the Power of Rivers: Sylvester Stewart—The Standard Yard: Bennett H. Brough—Experience with the Metric System on Railway Construction: F. Lavis, Assoc. M. Am. Soc. C. E.—The Metric System in Railway Construction: A. S. Robinson—The Use of Decimals with English Units of Measurement: C. W. Baldridge—How to Make a Quick Change to the Metric System: Harrison Everett Ashley—Metric Exaggerations: E. Sherman Gould—A Form of Pitot Tube for Measuring Air Velocities (illustrated): D. W. Taylor—A Method of Calculating Longitudinal Shear in Concrete-Steel Beams: S. D. Bleich 235-239

FURTHER INVESTIGATIONS of Jerome Park Reservoir construction will probably be made, as a result of a request to the Aqueduct Commission from Mr. Wm. R. Hill, M. Am. Soc. C. E., Chief Engineer. Under date of Jan. 30, 1903, Mr. Hill reported that a year previously, and after the receipt of the report from Messrs. Croes, Smith and Sweet, disagreeing from his views, that he had recommended "further investigation of the material underlying the site of the reservoir" before any definite plan was adopted to make water-tight the 1,190 ft. of heart-wall which Mr. Hill had declared to be built on quicksand. Mr. Hill now states that investigations made during the past year are such that he advises "expert engineering opinions on the boundary walls and embankments as built and projected." On Feb. 16 the Aqueduct Commission adopted a resolution requesting Mr. Nelson P. Lewis, M. Am. Soc. C. E., Chief Engineer of the Board of Estimate and Apportionment, and Mr. Nicholas S. Hill, Jr., Chief Engineer of the Department of Water Supply, to report as recommended by Mr. Hill.

WATER METERS IN NEW YORK CITY are authorized by a bill recently introduced in the State legislature. Two classes of meters are recognized—district meters, to be placed in the distribution system, and consumers' meters. As to the latter, the bill provides that they may be placed

in all stores, workshops, hotels, manufactories, office buildings, public edifices, at wharves, ferry houses, stables, and in all places in which water is furnished, wholly or in part, for business consumption, in all public structures, buildings and offices, in all buildings now wholly or in part exempt, or which may hereafter be declared wholly or in part exempt from water charges, and in all buildings over five stories in height, or where steam is generated for power purposes or where restaurants or cafes are maintained and conducted, and if authorized thereto by resolution or ordinance of the Board of Aldermen, in all apartment houses, tenements, flathouses and private dwellings, not included in one of the kinds of buildings and places before enumerated.

Test meters may be placed, at the discretion of the water commissioner, for a period of four months, and if such meters show that water is being used and wasted 50% in excess of what would be used under frontage rates if the latter allowed only 100 cu. ft. for each 10 cts. of such rates, then the meter may be retained, but the charge at meter rates (10 cts. per 100 cu. ft.) shall not begin until May 1 succeeding.

CIVIL SERVICE EXAMINATIONS will be held on April 4, 1903, for the following positions: Architectural draftsman, assistant electrical engineer, assistant steam engineer and quarry foreman for Erie county service. Persons desiring to enter these examinations must file applications in the office of the State Civil Service Commission in Albany before noon of March 30. Application blanks and information regarding salaries and requirements of examination may be obtained by addressing Charles S. Fowler, Chief Examiner of the Commission, at Albany, N. Y.

THE NUMBER OF MIDSHIPMEN at the Annapolis Naval Academy is to be doubled by permitting each senator and representative in Congress to appoint two instead of one. The age of admission is to be raised to 16 years, with a maximum of 20 years, as at present. The increase of the staff corps is to comprise one civil engineer, 12 assistant civil engineers and 29 naval constructors.

FIVE NEW BATTLESHIPS are provided for in the Naval Appropriation bill recently passed. Three of these vessels are to be of 16,000 tons displacement, and two of 13,000 tons.

STOPPING LEAKAGE IN DRY-DOCK No. 3, at Brooklyn Navy Yard, is to be attempted by forcing about 100 barrels of cement into the quicksand underlying the damaged portion of the dock.

A LEGAL DECISION of interest to contractors and engineers is one recently handed down in the suit brought by the U. S. Government against T. & A. Walsh, contractors for dry-dock No. 3, at the Brooklyn Navy Yard. The dock had been finished, the work accepted and the contractors had been paid in full, when leakage developed. Repairs were begun by the Government, and about $173,000 were expended for materials and labor. It was found that many of the piles driven were not the full length called for in the original contract, and suit was brought for this alleged defective work. Although samples of the short piles removed from the defective part of the dock were brought into court as evidence, a verdict was rendered in favor of the contractors.

THE DAMAGE TO TEMPORARY PILING in the East River by tug boats and the decision of the courts thereon, which was briefly noted in our issue of March 5, has been more clearly stated in information which has just come to hand. The piling referred to had been driven by the United Engineering & Contracting Co. in connection with the making of diamond drill investigations of the materials through which the Rapid Transit tunnel extension from Manhattan to Brooklyn is to be driven. The permits of the Rapid Transit Commission, transferred to the contracting company under its contract for the making of the investigations, were obtained from all the governmental departments having authority over the waterways of New York Harbor; were very complete, and the right of the contracting company to be in the river, not only with its floating equipment, but with its temporary stagings driven into the bottom of the river, was fully determined and acknowledged by the courts. The decisions of Judge Thomas referred to in the suit brought by the contracting company against the New York, New Haven & Hartford R. R. Co. for damage done the floating equipment and the staging by that company's transfer tug No. 5, and as well the decisions rendered in the other of the total of 21 cases that have come to trial, were these:

(1) The contracting company had a full right to proceed with its work, and anchor its scow, pile-drivers, etc., in the river, and to build the temporary staging.

(2) Damage in full was allowed, and judgment given to the contracting company for that which was inflicted upon the floating equipment.

(3) The court ruled that in the case of the staging, this being firmly driven into the bed of the river, it was in a condition similar to that of a vessel on a dry-dock, in which case the vessel, not being afloat, anything occurring on board would come under the jurisdiction of the civil courts, and could not be tried in the Admiralty courts. Therefore, the decision was that the United States District Court hearing Admiralty cases had no jurisdiction whatever over the staging, and the suits for recovery of damages must be tried in the civil courts. As a matter of fact, the damages awarded the contracting company for injury done its floating equipment have been settled in the cases that have been tried, and suit is now being instituted in the civil courts to collect the damages for injury done the staging.

THE MOST SERIOUS RAILWAY ACCIDENT of the week resulted from the collision of the two parts of a freight train, which broke in two near Olean, N. Y., on March 9. The train was loaded with tank cars of refined oil or gasoline and the collision burst some of the tanks, the contents of which caught fire. The heat of this fire caused some of the uninjured tanks to explode with great force, and the shock, burning oil and flying fragments of the cars and exploded tanks killed 14 and injured a large number of a crowd of spectators which had collected to witness the spectacular fire caused by the burning oil.

A WATER TANK FAILED on March 4 in Lincoln Pl., Mifflin Township, Pa. It was completed on Feb. 28 and appears to have been empty, when, according to the Pittsburg "Dispatch," "a heavy wind blew the tank from its foundation and made it a complete wreck." The tank belonged to the Chartiers Water Co.

THE ILLINOIS & MICHIGAN CANAL may be converted into a macadamized road if a bill now before the Illinois legislature is passed. While the traffic is practically nothing, and the canal has no influence in the regulation of railway rates, the expenditures for its maintenance continue to increase, although the canal is in a most dilapidated condition. In addition to its uselessness it is declared to be a "pestilent ditch," a detriment to public health, and a source of political corruption. Its value as a political asset is shown by the fact that an appropriation of $199,000 for maintenance is being asked for by the Canal Commissioners and urged mainly on the ground that the private water powers which the canal supplies must be continued. The decline of traffic on the canal is shown by the following:

	Boats.	Tons.
1899	70	403,352
1900	60	121,759
1901	41	81,456

THE RAILWAYS OF CANADA have a total extent of 18,808 miles, an increase of 574 miles over the year 1901. There are 358 miles of electric railway. The total revenue of Canada from Government works for 1902 was: Railways, $5,918,990; canals, $300,413; the working expenses were $5,861,099. The total expenditure on railways during the year was $13,407,152.

THE TRANS-SIBERIAN RAILWAY, which is 3,709 miles long, has cost $192,300,000, including the first order of rolling stock, but not including a subsequent appropriation of $47,160,000 for rolling stock.

ELECTRIC POWER IS SOLD in Shasta and Nevada counties, California, at $5 per HP. per month. The Comstock mines, in Nevada, pay $7 per E. HP.-month, and steam power generated by wood is said to cost $12 per HP.-month.

PUBLIC MEMORIALS TO ENGINEERS are not very common, at least not in this country. One in honor of Sir Joseph Bazalgette, placed on the face of one of the pedestals of the Victoria Embankment, was recently unveiled in London. A view of the memorial is shown in the London "Surveyor" of Feb. 27, from which the following description is taken:

It consists of a handsome mural monument wrought in veined Sicilian marble, containing a portrait bust in bronze of the eminent engineer. The base of the monument, rising from a sub-base of granite, consists of a carved panel, embodying in arabesque design the symbols of Science and Labor, while the central ornament, from which these enrichments spring, is formed of three dolphins, emblems of the tidal river. This center panel is flanked by two pilasters paneled and decorated with shields, and the whole is surmounted by a heavy molded cornice. About this are placed two taller pilasters with capitals formed of the bulrush and water iris, flanking the recess, in which is placed a bronze portrait bust of heroic size. In the recess, above the bust, hang garlands of laurel leaves also cast in bronze, while below the bust, and resting on the cornice of the base, is a bronze plaque or label, with the following simple inscription: "Sir Joseph Bazalgette, engineer of the London main drainage and of this embankment. Born, 1819; died, 1891." From either side of this label, and filling the space between it and the pilasters, rise bronze branches of oak leaves and acorns. The pilasters are decorated with sunk panels of arabesque, formed from the various instruments of the engineer and surveyor. Above all is the pediment, decorated with a shield between two palm branches, displaying the arms of the Bazalgette family, and a scroll bearing their motto.

THE YAZOO RIVER DIVERSION CANAL AT VICKSBURG, MISS.

Previous to 1876 the main channel of the Mississippi River formed the water front of the city of Vicksburg. The river coming east from the mouth of the Yazoo encountered a narrow spit of land known as Delta Point, which turned it north until the spit was outflanked and the stream swung east and south, passing the city on its way to the Gulf. During the siege of Vicksburg in the Civil War, General Grant cut a canal across this point of land near its base, with the idea in mind that the rising river would wash this cut larger and form a new channel which would leave the Confederate stronghold stranded and thus hasten its surrender. History has recorded how the river failed to meet the demand made upon it to ally itself with the Union General, and how other means were the cause of his final success. In 1876, however, the Father of Waters in one of his capricious moods did himself and without aid the task which he had been besought to accomplish a dozen years before. On Aug. 26 of the Centennial year the Mississippi broke through Delta Point, a couple of miles north of Grant's Canal, and in a day the city of Vicksburg found itself fronting on a shallow lagoon, one of those dead ends with which the great river has so thickly studded its changing course from Cairo to the Gulf. The blow to the river commerce of the city was a severe one and steps were at once taken to retrieve the loss. This has now been finally accomplished, after the passing of more than a quarter of a century, by the completion of the Yazoo River Diversion Canal by the United States Government.

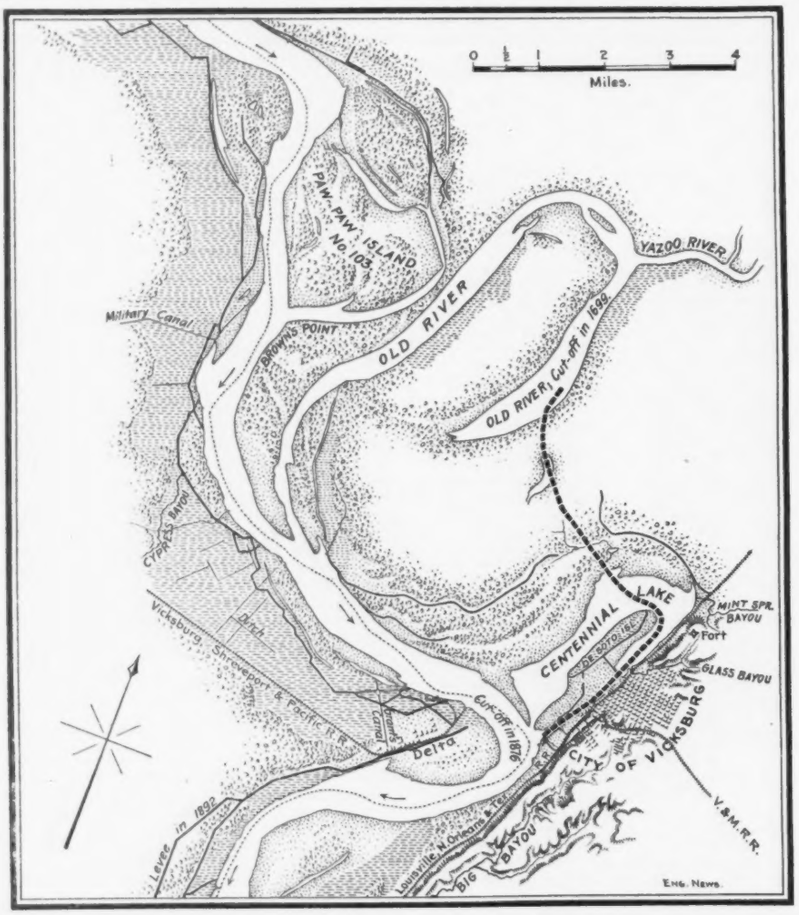


FIG. 1. MAP SHOWING GENERAL ROUTE OF YAZOO RIVER DIVERSION CHANNEL AND ADJACENT PORTIONS OF THE MISSISSIPPI RIVER.

HISTORY OF THE PROJECT.—As soon as the river had broken through Delta Point the south shore began to wear off gradually, and by July, 1877, the break was about 6,000 ft. wide. As the river receded to the south the old channel in front of the city began to fill up with sediment deposited by the eddy-current. Meanwhile, in June, 1877, the Chief of Engineers U. S. A., had appointed a board of engineers to consider remedies for the dangerous situation in which the river commerce of Vicksburg was placed. This board reported in January, 1878, recommending: (1) The protection of Delta Point from further caving and washing away; (2) the construction of a bar dike, and (3) the dredging of the inner harbor. It was estimated that this work would cost $254,000. In a supplementary report the board recommended a survey to determine the feasibility of diverting the current of the Yazoo River, so as to pass it around by the way of the old bed of the river in front of the city and so preserve the water front. This survey was made with money raised by the citizens of Vicksburg by private subscriptions, but the plan made no further progress for the moment.

Following the report of the board of engineers, efforts were made to secure from the United States Government a sufficient appropriation to carry out the work recommended to be done. In 1883 dredging was begun on the harbor channel; the protection of Delta Point had been previously accomplished, and the construction of the bar dike was a subsequent work. The map, Fig. 1, shows the conditions of the river and harbor as they were then. The dredging of the harbor channel, however, was not altogether a success as a means of improving the harbor, for sediment carried in at high water kept continually filling up the artificial channel. This condition of affairs soon caused agitation to be renewed for the construction of a diversion canal for the Yazoo River, and in 1890 the River and Harbor bill contained an appropriation of $5,000 for the survey of the mouth of the Yazoo and a study into the feasibility of diverting its flow past the Vicksburg water front. This survey was made in due course.

In 1894 a further appropriation of $75,000 was made by Congress to be expended in locating a route for the diversion canal, making borings, clearing the right of way, etc., and by the end of the year the final locating surveys had been completed. In the same year Congress further aided the project by placing the work under the continuous appropriation rule. From 1894 to 1900 a large amount of miscellaneous work was done on the project. This included a partial clearing of the right of way, some 388,000 cu. yds. of scraper excavation, a small amount of dredging, and some dike building. The real start toward rapid construction began, however, in June, 1900, when a contract was awarded to the Atlantic, Gulf & Pacific Co., of New York city, to complete the canal. The expenditure on the work previous to this date had been $202,405. The contract of June, 1900, called for the removal of 7,500,000 cu. yds. of material at a price of 12.4 cts. per cu. yd., but this yardage was subsequently reduced about 25% by a revision of the grades and cross-section of the canal. The time allowed the contractors for completing the work was 30 months.

DESCRIPTION OF THE WORK.—The route adopted for the diversion canal by the survey of 1894 is shown in its relation to the Yazoo and Mississippi rivers by Fig. 1. The effect of the canal it will be seen is to short-circuit the waters of the Yazoo River from the point where they enter the Old River to Kleinston point at Vicksburg. There is no damming of the old channel, the shorter and steeper routes of the new canal being depended upon to effect the diversion. To render the canal efficient for its purpose, and, particularly, to permit of its ready construction, a number of subsidiary works were necessitated. These are shown in connection with the canal route by Fig. 2, and will be described in their proper places. The canal, it will be seen, starts from the Mississippi River and passes north between the Vicksburg shore and De Soto Island. It then curves west around the head of the island and cuts through the divide between Lake Centennial and the Old River. At the Mississippi end the bottom of the canal is — 6 ft. on Kleinston gage, the zero of which is 45.2 ft. above Gulf level, and at the Old River end it is — 1 ft. on the same gage. The slope of the water surface of the canal is 6 ft. at low water and 1½ ft. at high water. The total length of the canal is 9.3 miles, divided as follows: Harbor section, 2 miles; Lake Centennial section, 1.6 miles; main cut, 3 miles, and Old River section 2.7 miles. The cross-section of the canal is 80 ft. wide on the bottom with side slopes

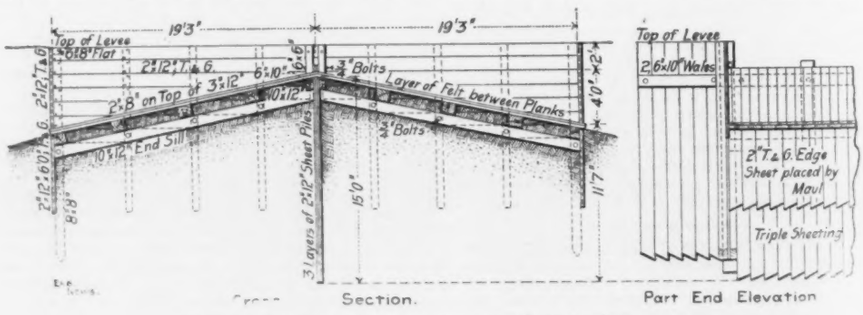


FIG. 3. DETAILS OF SPILLWAYS FOR IMPOUNDING DIKES.

of 1¼ to 1. Extreme high water of the Mississippi is +52.45 ft. on Kleinston gage and extreme low water is — 6.53 ft. on the same gage. To prevent the Yazoo waters from leaving the prescribed route of the canal and finding their way to the Mississippi through the West Pass of Lake Centennial a subaqueous dam was planned across the lake at a point about 2,000 ft. south of the canal center line and to have its crest at an elevation of + 16 ft. on gage.

PROGRESS AND METHODS OF WORK.—The plan adopted by the contractors was to do all the excavation by dredging and to begin operations at the Mississippi end of the canal and then to work north and west to the Old River end. There were several reasons why this plan of progress was deemed advantageous. In the first place it enabled work to be begun at once, since dredges could not be got into Lake Centennial until high water; secondly, it provided any advantage which might accrue to the city by having the first section of the canal to be completed lie along the city water front, and, third, it enabled the contractors to begin at once and during low water the structures necessary to impound Lake Centennial.

The object of impounding Lake Centennial was to maintain there during the low water season a sufficient depth of water to permit dredging in the main cut. It was decided to impound by raising the old Jackson St. dike shown at A, by building the new dike B C, and by damming the east outlet of West Pass. The west outlet of this pass had been dammed in 1899. The Jackson St. dike was raised to elevation + 32 ft. on Kleinston gage and the new dike B C to elevation + 29 ft. The idea in building these dikes was that they would be overtopped during high water, and, when high water receded, that they would impound a sufficient volume and depth to permit dredging operations until the next high water season. The dikes being constructed of earth it was perceived that the time of greatest danger to their integrity would be just as they were being overtopped by the rising water and just before the falling water ceased to flow over them. To obviate this danger a spillway, 75 ft. long, and with its crest at elevation + 27, was built in the dike damming the east mouth of West Pass, and another 50 ft. long, with its crest at elevation + 27.6, was built in the Jackson St. dike. These spillways were temporary structures and their construction is shown by Fig. 3.

throughout. The clay was delivered from the discharge pipes in rounded lumps and was the principal factor in the dike building. Up to March 19, 1901, the dredges removed 1,026,743 cu. yds. from the harbor section of the canal. They were then towed to the north end of Lake Centennial and began work on the main cut. The view, Fig.

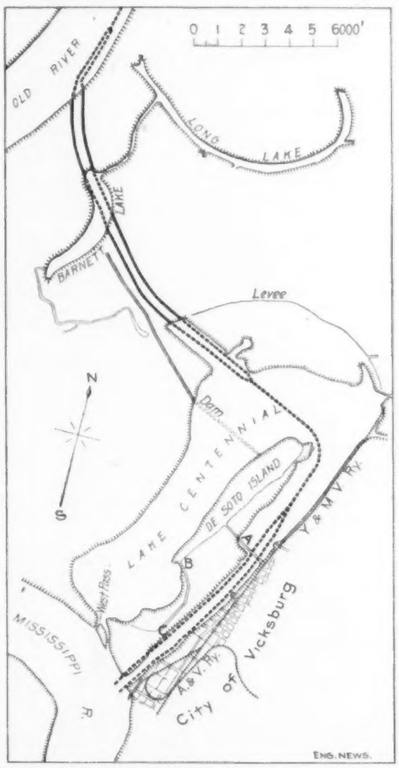


Fig. 2. Map of Diversion Channel and Subsidiary Works.

4, shows the two dredges at work on the harbor channel during the low water season. The view is one looking toward the Mississippi River, with Vicksburg on the left and De Soto Island to the right.

Lake Barnett. That taken out by the clam-shell dredge was employed at first to form the impounding dam in the east mouth of West Pass and afterwards in building the Lake Centennial subaqueous dam. The view, Fig. 5, shows one of the hydraulic dredges working through the shoals at the north end of De Soto Island on its way toward the entrance to the main cut. Fig. 6 is a profile of the main cut and shows the depth of excavation required.

The subaqueous dam in Lake Centennial is shown in location by the map, Fig. 2. It was built by depositing from scows the material taken out of the bottom portion of the main cut by the clam-shell dredge. The crest of the dam has an average elevation of 53½ ft. above mean Gulf level and the depth of fill varies from 2 ft. to 34 ft., with an average of 16 ft. The characteristic cross-section at the high points of the dam has a crown of 30 ft. and side slopes of 1 on 7 for the first 10 ft. below the crest and of 1 on 20 for the remainder of the depth.

For the most part the excavation of the diversion canal was straight forward dredging. There was some trouble from the breaching of the impounding dikes, and the usual minor delays and accidents inseparable from works of this character and magnitude. The canal was practically completed by the end of 1902. The connection of the harbor cut with Lake Centennial was made on Dec. 10, 1902, by breaching the Jackson St. dike, and a view of this operation is given by Fig. 7.

DESCRIPTION OF DREDGES.—As already indicated, there were used on the work two centrifugal dredges and one clam-shell dredge. The hydraulic dredges are shown by Figs. 4 and 5, and are substantially twin vessels. They are both 20-in. dredges and showed capacities of 260 and 290 cu. yds. per hour on the present work. The clam-shell dredge is shown by Fig. 8, and presents only two features that may be considered novel in this type of excavator. In addition to the usual anchor spuds (port, starboard, and stern) there is a walking spud aft, on starboard side, by means of which the dredge can be swung through any arc on the stern anchor spud as a center. This feature has enabled the dredge to make a cut 225 ft. wide.

To prevent the bucket from twisting on its cables, a chain has its ends attached to the two halves of the bucket at points as far apart as practicable, the chain being of such a length as to

FIG. 4. HYDRAULIC DREDGE WORKING IN HARBOR CHANNEL DURING LOW WATER IN MISSISSIPPI RIVER.

Dredging was begun at the Mississippi end of the canal on Nov. 19, 1900, and on Dec. 17 following a second dredge began work. These dredges continued at work in the harbor channel until March 19, 1901, and their discharge was employed chiefly in building the impounding dike B C, Fig. 3. The material dredged varied from blue clay to soft loam with a small admixture of fine sand

The plan adopted for making the main cut was to take out the top cut with the hydraulic dredges and then to deepen the prism with a clam-shell dredge, which had been built at Vicksburg by subcontractors during the winter of 1901. The material taken out by the hydraulic dredges was employed in building a training dike along the south bank of the main cut and in forming a dam across

hang in a short loop or bridle. A small cable runs from the middle of this chain, through a sheave near top of the A-frame supporting the boom, and thence to a weight sliding on a fixed vertical cable. Should the bucket start to turn, one side or the other of the chain bridle will be drawn taut, and if the counterweight is sufficiently heavy the turning movement will be checked. This

device originated with Mr. J. D. Harris, a leverman on this dredge. This dredge showed an average capacity on the work of about 100 cu. yds. per hour.

CONCLUSION.—As already stated, the diversion canal was practically completed during 1902. The original contract called for the removal of 7,500,000 cu. yds. of material, but a change made subsequently in the grades and cross-section of the canal reduced the amount to about 5,655,000 cu. yds. Of this all but 155,000 cu. yds., which remains in the harbor channel, has been completed. The total cost of the work has been about $1,200,000.

THE COST OF PUMPING AT THE SHORT MOUNTAIN COLLIERY OF THE LYKENS VALLEY COAL COMPANY.*

By R. V. Norris, M. Am. Inst. Min. E., Wilkesbarre, Pa.†

The great coal strike of 1902, which confined the work at the Short Mountain colliery of the Lykens Valley Coal Co. almost exclusively to pumping, gave an opportunity to determine with considerable accuracy the cost of pumping the water from these very old, extensive and wet mines.

This colliery, which is located in the extreme southwestern end of the anthracite coalfield, has been operated continuously since 1836, and has shipped 7,747,313 tons of coal. This and the Williamstown colliery are the only operations in Dauphin county.

The workings cover about 5 miles along the north dip of the extreme westerly end of the basin, with the operating slopes near the center. They extend around the westerly spoon of the basin and back about 3¼ miles easterly on the south dip. The mines are very deep, the present workings extending to 711 ft. below sea-level, and about 1,600 ft. below the lowest surface-opening.

The coal is hoisted principally from the Short Mountain slope, which is 1,550 ft. long, with 26° to 68° dip, and from an inside slope, No 4, 800 ft. long, with 52° to 72° dip. The ordinary capacity of the colliery is about 1,000 tons per day, and the average output for the years 1897 to 1901, inclusive, was 297,000 tons per year.

The pumping plant is divided into four lifts. The greater part of the water is caught on the No. 3 level and pumped from there to the surface. The pumps on the No. 4 level only handle, on an average, one-third of the total water pumped to the surface. Excepting the bottom lift, the pumps are all simple, direct-acting, and many of them have been in place for a number of years. This plant, while not claiming to be modern or very economical, is a very fair sample of the average plant in use in the great majority of the older and deeper slope collieries in the anthracite region. In fact is is, if anything, rather above the average.

The boiler plants were tested in May, 1898, and the evaporation per lb. of fuel (Nos. 2 and 3 buckwheat coal) was found to be: For cylinder boilers, 5.51 lbs. and for Babcock & Wilcox boilers, 6.89 lbs. water at actual temperatures and pressures, equivalent to 7.75 and 9.22 lbs., respectively, from and at 212° per lb. of combustible. These tests are used here as a basis for deducing the quantity of steam used by the plant as a whole.

The pumps are as follows:

Level	No.	Maker	Size. Steam. Inches.	Water. Inch.	Stroke. Inches.	Size Column. Inches.	Vertical Lift, including Suction Feet.	Capacity Gallons Per Min.	
4	1	Jeansville Comp. Duplex.	24 and 38	10	36	10	673	857	1714
4	2	Jeansville Comp. Duplex.	25½ and 38	10	36	10	660	857	
3	1	Allison & Bannan. Single.	27	12½	108	8	321	692	3671
3	2	Allison. Single.	27	12¼	72	10	321	737	
3	3	" "	38	16	72	12	326	1086	
3	4	" "	30	14½	72	10	326	1156	
2	1	" "	36	16½	72	12	331	1131	
2	2	Allison & Bannan. Single.	26	12½	72	8	331	658	3817
2	3	Allison. Single.	38	16½	72	12	328	1131	
2	4	" "	30	12¼	72	8	328	897	
1	1	Bull Pump.	44	21½	110	20	319	866	
1	2	Griscom Duplex.	22	9⅞	36	10 and 12	318	1032	3755
1	3	Carter & Allen.	26	11⅝	72	8	203	852	
1	4	Allison.	38	16½	72	14	317	1005	

The records of the actual water pumped (plunger displacement) are accurately kept by counters on each pump; also the labor cost of pumping, and the cost of repairs and supplies to pumps. At the boiler plants the labor, repair and supply accounts and the total coal used for steam at the colliery are accurate; but there has been, until recently, no practical way of dividing the total steam cost between pumping and the other manifold colliery uses.

During June, July and August, 1902, practically all of the steam generated at the colliery was used in pumping. During this time 7,692 tons of coal were used for firing, of which it is estimated that 232 tons were used in supplying steam for accommodation hoisting, ventilation and in condensation in unused steam lines, leaving 7,360 tons for generating steam for pumping. During these three months 207,034,324 gallons were pumped from an average depth of 1,152 ft., making an average of 0.035 ton of coal per 1,000 gallons. On this basis, correcting for average depth and for use of different proportions of cylinder and Babcock & Wilcox boilers, we find for the years 1901 and 1902 as follows (1901 being corrected for 7.8% less efficient boiler plant and 1% greater depth, and 1902 for 2.6% less efficient plant and 5.3% less depth):

	1901.	1902.
Total water pumped,* gallons.	567,113,616	1,116,320,253
Average depth pumped, ft.....	1,141	1,093
Total estimated coal used, tons	23,537	37,963

*Plunger displacement.

This estimate is checked by the total coal used for firing: For 1901, 41,288 tons, and for 1902, 49,149 tons; the difference being, for steam uses other than pumping, for 1901 (12 months' work), 17,751 tons, and for 1902 (7½ months' work), 11,186 tons, which is equivalent to 17,888 tons for 12 months.

As the average evaporation of the plant, with the proportion of cylinder and water-tube boilers in use during June, July and August, 1902, was 6.64 lbs. of water per lb. of fuel, based on the tests of 1898 above referred to, the total steam made during these three months was about 109,470,000 lbs.

The foot-pounds of work used in pumping were 1,987,529,500,000; the duty of the pumps was about 18,150,000 ft.-lbs. per 1,000 lbs. of steam made by the boilers, which should be increased by at least 15% for steam used in Argand blowers and condensation in steam lines, giving as the approximate duty of the pumping plant 20,880,000 ft.-lbs. per 1,000 lbs. of dry steam delivered at the pumps.

Dividing the total cost of making steam between the colliery and the pumping plant in proportion to the coal used, namely, 57% in 1901 and 77% in 1902, the total cost of pumping was as follows:

	1901.	1902.
Total cost of labor, supplies and repairs for generating steam.....	$22,060	$19,728
Per cent. used for pumping	57	77
Cost of labor, supplies and repairs*....	$12,574	$15,191
Coal used, 23,537 tons, at 50 cts. per ton	11,768	
Coal used, 37,963 tons, at 50 cts. per ton		18,981
Total cost of steam for pumping.....	$24,342	$34,172
Cost of labor, supplies and repairs†....	8,915	12,236
Total cost of pumping.....	$33,257	$46,408
Total cost per 1,000 gallons.....	0.0588	0.0416
Average vertical lift, ft	1141	1093
Cost per 1,000 gals., 1,000 ft. vert. height	$0.0533	$0.039

*In generating steam for pumping only.
†For pumping plant.

steam used will vary directly as the lift, and that the labor cost of pumping will not be affected by the slight change in average lift.

While no claim is made for anything like scientific accuracy in the foregoing figures, I am satisfied that they are a very close approximation to the truth, and the method of arriving at them is given so fully that the probable amount of error, which can only be in the division of the steam account, can be readily seen; further, only those familiar with anthracite work can imagine the difficulty of getting information even as accurate as this. In 17 years' practice I have been unable, until now, to arrive at even an approximate cost for pumping of this character and extent.

The object of this investigation was to determine the probable saving in operating expenses in replacing this plant by a more modern one with compound condensing pumps and higher lifts, which it is now figured will reduce the cost of pumping to about 3 cts. per 1,000 gallons (for 1,000 ft. vertical lift) in dry years like 1901, and to 2.2 cts. in flood years as 1902, at a cost of about $120,000.

FIG. 5. HYDRAULIC DREDGE WORKING IN LAKE CENTENNIAL APPROACHING MAIN CUT.

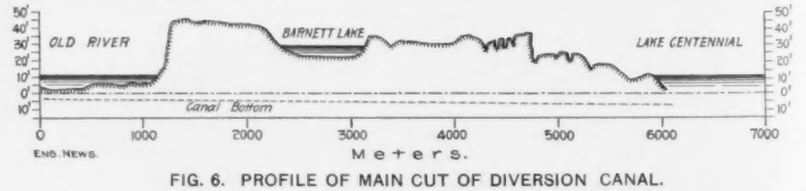


FIG. 6. PROFILE OF MAIN CUT OF DIVERSION CANAL.

*A paper read before the American Institute of Mining Engineers.
†Chief Engineer P. R. R. Coal Co., 40 S. Franklin St., Wilkesbarre, Pa.

The average amount of water pumped at this colliery ranges from 2,000 to 4,000 gallons per ton of production, and the maximum in wet months has reached as high as 8,000 gallons, or 30 tons of water for each ton of coal shipped from the colliery; and, for the flood year, 1902, when the production was cut down by the strike, reached 8,940 gallons, or 33⅓ tons for each ton of coal produced. The coal used for steam purposes is in average years about 15%, and in 1902 was 40% of the shipments of the colliery.

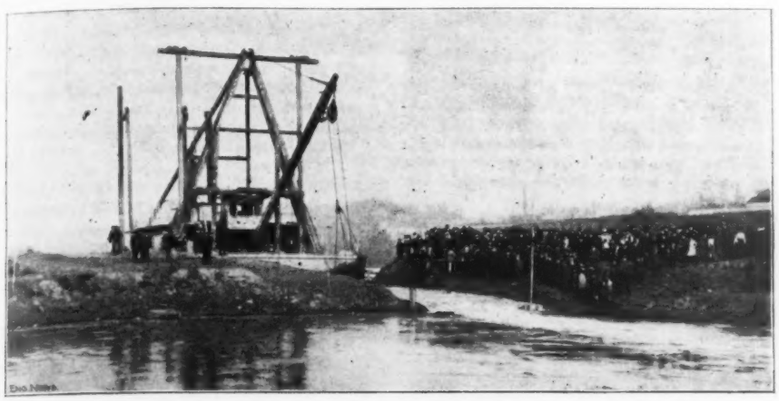


FIG. 7. FINAL BREACHING OF DIKE SEPARATING HARBOR CHANNEL FROM LAKE CENTENNIAL.

The cost of pumping at the Lehigh Valley Coal Co.'s Hazleton shaft plant, of high duty, with 5,000,000-gallon pumps, is said to be about 1½ cts. per 1,000 gallons for 560 ft. vertical lift, and this is almost unquestionably the highest grade pumping plant in the anthracite region.

A COMPARISON BETWEEN EYE-BAR CHAINS AND WIRE CABLES FOR SUSPENSION BRIDGES.

By Wilhelm Hildenbrand, M. Am. Soc. C. E.*

In the semi-annual report of Bridge Commissioner Lindenthal on the progress of the New East River bridges, he announced that the plans of the "Manhattan" bridge, now in course of construction, had been revised by substituting eye-bar cables for the wire cables, originally designed by Mr. R. S. Buck, the former chief engineer of the bridge. This alteration was justified with the following remark:

In view of the fact that wire cables have proved to be a source of great delay in construction of the Williamsburgh Bridge, and also with a view of greater economy, the plans for this bridge were revised, so that cables may be used of forged eye-bars of a high-grade steel, in combination with a more effective system of stiffening, from which greater economy in construction (and thereafter in maintenance) will result.

This summary statement might be accepted, unquestioned, by a private company from its chosen engineer, and in that case would probably remain unchallenged; but coming, as it does, from the Commissioner of Bridges of the City of New York, and involving the expenditure of several millions of dollars of public money, the citizens and officers of this municipality would do well to pause a moment, and not to sanction the proposed new plan, until unmistakable proofs of the correctness of the Commissioner's statements are placed before them.

The two reasons and only arguments advanced by the Commissioner for justifying the application of eye-bar cables to a large structure like the Manhattan Bridge, viz.: avoidance of delays and economy of cost, are not only untenable, but they are in direct contradiction to the actual facts! The writer is prepared to demonstrate that the construction of wire cables for the Williamsburg Bridge has not caused any, not even the least, delay, and that the substitution of eye-bar chains for wire cables would have added to the cost of this bridge, at the lowest estimate, from two to three millions of dollars!

Before proving these two assertions, it may be instructive to mention some facts which show that the subject of this discourse should not be disposed of by a mere statement, but that it is worthy of a thorough investigation.

Eye-bar cables are not a novelty; they have been used in Europe almost exclusively, and in America frequently, in the construction of small suspension bridges. One of the largest bridges of this kind is the well-known "Point Bridge" at Pittsburg, which has a span of 800 ft., and which in its main principle of construction is very similar to the proposed Manhattan Bridge.

Mr. R. S. Buck, former chief engineer of the Manhattan Bridge, and Mr. L. L. Buck, former chief engineer of the Williamsburg Bridge, both bridge builders of high reputation, adopted wire cables, stiffened by trusses, as the principal feature of their designs. As these two gentlemen, though accidentally of the same name, but not related, were working independently of each other, it must be supposed that both arrived at their conclusions after profound meditations, and numerous calculations, and that they had no other reason for adopting wire cables than their professional conviction that the interest of the city would be served best by a construction which, in their opinion, combined the greatest economy with the greatest efficiency.

Mr. L. L. Buck is the engineer who removed two well-preserved wire cable bridges over the Niagara River and replaced them by steel arches, from which fact, it may be inferred, if his sentiments in this respect were not already known, that he is no particular friend or advocate of wire cables, and that he would have adopted another construction for the Williamsburg Bridge if he could have done so conscientiously without acting against his best judgment and against the interest of the city.

Another authority on bridge construction, Professor Mehrtens, of Dresden, Germany, stated his views on eye-bar chains and wire cables in a lecture delivered on Nov. 2, 1897, at Frankfort-on-the-Main, before the German Technical Society. Referring to the competitive designs for a new bridge across the Danube, at Budapest, he said:

Though the first prize was awarded nearly three years ago to Chief Engineer Kuebler, of Esslingen, for his design of a wire cable bridge stiffened by trusses, it seems that the technical authorities in Budapest are still undecided whether to give preference to eye-bar chains or to wire cables. Inasmuch as a chain bridge (for various reasons which I will not itemize here) will be considerably more expensive than a cable bridge, it is to be hoped that the final decision will be in favor of the latter.

The high professional standing of the three engineers mentioned above, whose opinion is decidedly against eye-bar chains, should be convincing evidence that the claim for economy in eye-bar chains is not only questionable, but more probably unjustified, and that it cannot be sustained by facts or figures. On the other hand it is not difficult to demonstrate by simple calculations that the economy is decidedly on the side of wire cables, and that, with our present knowledge of the qualities and values of structural material, it is absolutely impossible to construct a suspension bridge supported by eye-bar chains at a cost which is not from 30 to 40% greater than the cost of a wire cable bridge of equal size, capacity and safety.

The writer has prepared these figures which he submits, herewith, to the profession and to the general public, hoping that they will fully elucidate the subject and eventually be the means of saving to the city's treasury at least two millions of dollars.

The calculations proving this assertion can be understood by anybody, without requiring technical knowledge. The figures are not derived from complicated theories, but they are merely based on the relative proportions of weights, which, for themselves, are subjected to the two following simple and indisputable rules:

(1) The weight of a cable or chain is directly in proportion to the total weight of the bridge.

(2) The weight of a cable or chain is inversely in proportion to the strength of the material it is made of.

After the relative strength and value of eye-bar material and of cable material has been established, it will be an easy matter, with the help of these two principles, to calculate and to compare the relative cost of the two types of bridges under consideration.

The acknowledged best and most reliable steel for structural purposes, which is at present in the market, was described in the specifications of the Williamsburg Bridge as "acid open-hearth steel" made by the "pig and ore" process. The principal

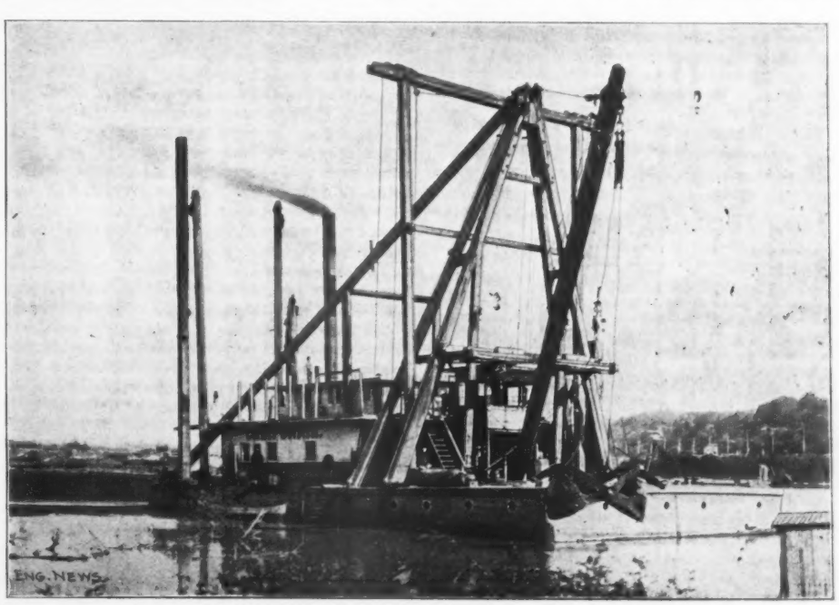


FIG. 8. VIEW OF CLAMSHELL DREDGE WORKING ON YAZOO DIVERSION CANAL.

*Engineer of Cable Construction for John A. Roebling's Sons Co., South Sixth St. and Kent Ave., Brooklyn, N. Y.

qualities of this steel, in the shape of bars and angles, are:

Maximum ultimate strength = 68,000 lbs. per sq. in.
Maximum limit of elasticity = 35,000 lbs. per sq. in.

In the shape of wire the same class of steel has the following qualities:

Minimum ultimate strength = 200,000 lbs. per sq. in.
Minimum limit of elasticity = 180,000 lbs. per sq. in.

This shows that wire has three times the strength and five times the elasticity of eye-bars made of the same steel. Since engineers have decided long ago to gage the safety and life of a bridge not by the ultimate strength of the material but by its limit of elasticity or "yield point," it follows that an eye-bar cable, made of the best steel in the market, must be at least five times heavier than a wire cable for sustaining the same weight with an equal margin of safety.

Another high grade of steel, containing 3½% of nickel, was described by Mr. Geo. S. Morison, in a paper read before the American Society of Civil Engineers on Oct. 21, 1896, to possess an ultimate strength of 100,000 lbs. and an elastic limit of 60,000 lbs. per sq. in. Such steel has been manufactured in this country in large quantities for armor plates for the U. S. government, but, so far, it has never been used for structural purposes. However, Mr. Morison considers it feasible that nickel steel can be used successfully for bridge structures, and on his authority the writer will assume that the manufacture of eye-bars, of the quality as specified by him, is an established fact. There is no reason to doubt that the same kind of steel could be worked into wire with a proportionate increase of strength and elasticity, which would leave the relative qualities of eye-bars and wire the same as before, but, for the sake of placing all possible arguments in favor of eye-bars, the writer will compare the prospective qualities of nickel-steel bars with the actual qualities of steel wire, as ordinarily used in cable construction. In other words, it will be assumed, in the subsequent calculations, that an eye-bar cable can be constructed of which the useful sectional area must be only three times larger than that of a wire cable, which is the very best assumption that it is possible to make in favor of eye-bar chains.

As the writer has only a general knowledge of the new plan for the Manhattan Bridge, while he is fully acquainted with all details of the Williamsburg Bridge, he proposes to show how much more the latter bridge would have cost if it had been built on the plan proposed for the Manhattan Bridge instead of on its present plan. Both bridges are almost of the same size and capacity, hence what is true for one bridge must also be true for the other.

The following are the weights of the Williamsburg Bridge:

Dead load, exclusive of cables, = 12,512 lbs. per horizontal lin. ft.
Live load = 5,700 lbs. per horizontal lin. ft.
Cables = 3,120 lbs. per horizontal lin. ft.
Total, 21,332 lbs. per lin. foot.

If the section of the cables could be varied in accordance with the variation of the stresses, the weight of the cables would be only 2,991 lbs. per lin. ft., which may be considered the necessary weight of cables for sustaining a total load of 21,332 lbs. per lin. ft. The weight of eye-bar chains, for supporting the same load, must be three times larger in their useful section, to which a certain percentage for eyes and pins must be added. This extra weight amounts in ordinary link chains to from 20 to 25%, but, on account of the extremely long links, designed for the Manhattan Bridge, as shown in the published plans, it is reduced to about 17%. In the stiffening construction for the Manhattan Bridge the chains perform the duty of truss-chords, hence the weight of the top chords of the stiffening trusses can be omitted. Otherwise the weight of the superstructure of a chain-cable bridge must be precisely the same as that of a wire cable bridge. The floor system is the same and, as the bending moments and shear forces are independent of the stiffening system, the bottom chords and web system must weigh the same as the bottom chords and web system of the stiffening trusses. The revised weights are:

	Lbs. per lin. ft.
Dead load without top chords of trusses	11,210
Live load	5,700
Total load, exclusive of eye-bar chains	16,910

If (x) denotes the useful weight of the eye-bar cable, it is easily determined, in accordance with the two rules given above, by the following proportion:

$$\frac{x}{16{,}910 + \left(x + \frac{17\,x}{100}\right)} = \frac{3 \times 2{,}991}{21{,}332}$$

	Lbs. per lin. ft.
From which we find x =	14,006
Add 17%	2,381
Actual weight of chains	16,387

Therefore, total weight of bridge = 16,387 + 16,910 = 33,297 lbs. per lin. ft. This is 56% more than the present weight of the Williamsburg Bridge.

Eye-bar chains, to support the same loads with the same factor of safety, are 5¼ times heavier than wire cables!

The greater tension in the chains, produced by the greater weight, necessitates heavier anchor chains, larger anchorages, heavier steel towers and larger foundations.

For a tension in the cables of 20,572 tons, an anchor chain was constructed weighing 997 tons. For the proposed eye-bar chain the tension will increase, in the proportion of 21,332: 33,297, to 32,117 tons and, therefore, the weight of the anchor chain to 1,556 tons, containing 559 tons of steel more than now. The lowest estimate for the cost of this additional weight in both anchorages will be: 2 × 559 × $60 = $77,080—(1). Each of the present anchorages contains 55,000 cu. yds. of masonry to withstand a tension of 20,572 tons, hence for resisting a tension of 32,117 tons the quantity of masonry should be 85,860 cu yds. or 30,860 cu. yds. more than now. The contract price for this stone work,, supposed to be only inside masonry, was $7 per cu. yd., hence the additional cost of both anchorages will amount to 2 × 30,860 × $7 = $432,040—(2).

Each steel tower of the Williamsburg Bridge supports the following maximum weight:

	Tons.
Superstructure and cables: 1,000 × 21,332 lbs. =	17,066
Weight of tower 300 ft. high	3,000
	20,066

On the alternate plan this maximum weight will be:

	Tons.
Superstructure and chains: 1,000 × 33,297 lbs. =	26,638
Weight of tower	3,930
	30,568

The towers, as constructed now, weigh 10 tons per lin. ft., divided about evenly between the columns and lateral bracing. The latter needs no reinforcement, but the weight of the former should be increased in the proportion of 20,006 : 30,568, which will raise it from 5 tons per lin. ft. to 7.6 tons, hence the whole tower will weigh 12.6 tons per lin. ft. Inasmuch as four eye-bar chains will occupy a space of over 20 ft. in width, which would be a serious loss of room on the floor of the bridge, the cables must be suspended in sufficient height to give clear headroom under their lowest point. This requires an extra height of 12 ft. over what the towers are now, hence the total weight of one tower will be: 312 × 12.6 = 3,931 tons.

The contract price for the towers was 5 cts. per lb., and the increase in cost, therefore, will be: 2 × 931 × $100 = $186,200—(3).

The pressure on the foundation of one tower of the Williamsburg Bridge is the following:

	Tons.
Weight of tower	3,000
Superstructure	20,066
13,637 cu. yds. of masonry	27,568
13,784 cu. yds. of concrete	21,819
Weight of end spans	1,365
	73,818

The foundation, divided into two piers, is spread over an area of 9,813 sq. ft.; hence the pressure per sq. ft. is 7½ tons.

In the eye-bar bridge the pressure would be:

	Tons.
Weight of tower	3,931
Superstructure	26,638
13,637 cu. yds. of masonry	27,568
3,614 cu. yds. of additional masonry	7,229
13,784 cu. yds. of concrete	21,819
3,614 cu. yds. additional concrete	5,782
	92,967

If the pressure shall not exceed 7½ tons per sq. ft., it requires a foundation of 12,400 sq. ft. and in the whole height of the pier, which is 100 ft., 7,229 cu. yds. of additional material, divided about evenly into masonry and concrete. The extra cost, therefore, will be:

2 × 3,614 cu. yds. of masonry at $10 =	$72,280
2 × 3,614 cu. yds. of concrete at $5 =	36,140
For additional excavation and larger caissons	44,900
	$153,320—(4)

The length of the Williamsburg Bridge from anchorage to anchorage is 2,834 ft., therefore the total weight of the eye-bar chains will be: 16,387 lbs. × 2,834 = 46,440,758 lbs. As no eye-bars of nickel steel and of dimensions, as designed for the Manhattan Bridge, were ever manufactured, the cost of these chains can only be assumed by certain probabilities, based on the price of steel as used in the Williamsburg Bridge. According to Mr. Morison's statement, in the paper mentioned above, the price of nickel steel will be 2 cts. a pound more than that of ordinary steel, or 7 cts. a pound, 5 cts. being the contract price for the steel work of the superstructure of the Williamsburg Bridge delivered in New York.

The cost of erection can also be only a matter of conjecture, but judging by the erection cost of said superstructure, which is 2.23 cts. a pound, the writer thinks that 2 cts. for erecting the chain, or 9 cts. in all, will be a conservatively low assumption. It must be considered that in building the superstructure of the Williamsburg Bridge (now in course of erection) no false works or other special machinery were required, two ordinary traveling derricks being the only erection outfit, while for erecting an eye-bar chain the construction of a temporary bridge for supporting the first set of links will be necessary.

The footbridge, built for spinning the wire cable, which had practically no load to carry, except its own weight of 500 tons in the main span, has cost $100,000. A footbridge used as false works for erecting the eye-bar chain must carry a load of at least 800 tons besides its own weight and it is safe to say that such a bridge will cost about $225,000 to $250,000, or over one-half a cent per pound on the total weight of the chain. This leaves for the real erection work less than 1½ cts. per pound, which is probably much less than any firm would be willing to do it for.

The total cost of the eye-bar chain, therefore, will be 9 ÷ 100 × 46,440,758 = $4,179,668. The actual price paid for the wire cables, including suspenders, was $1,398,000, hence the increased cost of cables, $2,781,668.

As the chains take the part of top chords of the stiffening construction, the cost of the latter must be subtracted, amounting to $\frac{1{,}302 \times 2{,}834 \times 4.23}{100}$ = $266,777, leaving the increased cost of cables = $2,514,891—(5). Summing up, we have:

Extra cost for	anchor chains	$77,080 (1)
" " "	anchorages	432,040 (2)
" " "	towers	186,200 (3)
" " "	tower foundation	153,320 (4)
" " "	cables	2,514,891 (5)
Total		$3,363,531

Considering that the steel and stone work of the total bridge, from anchorage to anchorage, has actually cost only $6,149,315, an increase of more than $3,000,000 or over 50%, merely for substituting eye-bar cables in place of wire cables, is certainly such a large amount of money that it will cause this community to pause and to think twice before making such a substitution. To justify this extra outlay, what may be called a waste of money, very material benefits should be obtained from the use of eye-bar cables; but this is not the case, and it will be demonstrated later on that not a single benefit will be derived from eye-bars that is not equally well derived from wire cables.

The writer wants to have it understood that he is not reviewing the general design of the Manhattan Bridge, still less is he criticising the same; he merely made a comparison between wire cables and eye-bar cables under exactly similar conditions of loads, stiffness, unit stresses, pressure on foundations and margin of safety, and he has shown that, applied to the case of the Williamsburg Bridge, the adoption of nickel-steel eye-bar

cables would have resulted in an increase of cost of over 50%.

The actual figures, as given above, may undergo considerable modifications, according to different conditions and different assumptions, but the ratio of cost between the two types of bridges will in all cases remain the same!

It is claimed that the construction of wire cables causes delays. This assertion can be contradicted simply by stating facts, which are:

The first wire for the cables of the Williamsburg Bridge was taken across the river on Nov. 27, 1901, and the spinning of cables continued every day for seven months, uninterrupted by anything except such weather in which no kind of outdoor work is possible, until on June 27, 1902 the last wire was laid in the cables. Where was the delay? There was none; and any statement that there was one can only be based on ignorance of the truth or on wilful misrepresentation.

In order to spin cables, some preliminary work is necessary, like erecting a footbridge and placing in position some kind of hoisting machinery. Whether any delay occurs or not in the erection of these appliances, that has absolutely nothing to do with cable making itself. The same, and even more extensive, auxiliary structures are necessary for building an eye-bar chain, therefore, delays or no delays, whatever happens in the erection of those auxiliary structures, applies equally to either type of cable construction.

A comparison between the time of building a wire cable or erecting an eye-bar chain must be made after all preliminary work is finished

On one side we have the following fact: Four wire cables of 18¾ ins. diam. have been constructed in seven months, as demonstrated at the Williamsburg Bridge. The writer is confident that, at another opportunity, the time of spinning can be reduced to six months, and that in seven months the cables can be made complete, ready for suspending the floor system.

On the other side we have the question: How long will it take to erect four eye-bar chains which are five times heavier than wire cables? The task has never been performed under conditions as existing at the East River, and the time it will require can only be a matter of conjecture. It is the opinion of the writer that it will require fully as long as the construction of wire cables. However, taking a very optimistic view in favor of eye-bar chains, and supposing that they could be erected in four months less time than wire cables, what advantage would that be to the city? This question can be answered by a simple calculation. At the time when the cables for the Williamsburg Bridge were commenced the city had expended $3,600,000, representing an interest of $10,500 per month, hence a saving in time of four months would save to the city $42,000 in interest, but in order to do so it would have to spend over three millions of dollars.

Another argument which has been advanced in favor of eye-bar chains is that the pin connection of the links forms an absolute and positive attachment for the web system of the stiffening construction, while the attachment to cables must be made by means of friction. To this argument can be replied: If a cable should really be unfit for the proper attachment of diagonal braces, why should such a method of stiffening be used when there are others equally good? Would it be justifiable to spend several millions of dollars merely for favoring a certain kind of stiffening construction? However, it can be demonstrated that it is not necessary to discard wire cables on that account. A friction attachment can be made which is safe and effective for all requirements. A committee of three eminent engineers, consisting of Messrs. L. L. Buck, Geo. S. Morison and C. C. Schneider, M.'s Am. Soc. C. E., recently appointed by the Commissioner of Bridges to examine into the best methods for repairing the cables of the Williamsburg Bridge which were somewhat damaged by fire, have decided that a number of wires could be added to each cable by attaching them to a cable band, clamped to the cable with bolts. These bands would give sufficient friction for a safe, efficient and permanent connection.

The same kind of clamp, if made sufficiently strong, will answer for the attachment of posts and diagonal braces. The maximum shear force at the Williamsburg Bridge was calculated to be 531 tons, or 133 tons per cable. To transmit this force by a diagonal tie will, according to the rules adopted by the above-named committee, require a cable band 4 ft. long, with seven 2½-in. bolts in a row on each side of the cable. There is nothing in this construction that is not feasible. Besides, there are other simple means for preventing a band from slipping.

If preference be given to the kind of stiffening construction as designed for the Manhattan Bridge, it is, therefore, not necessary to rely solely on eye-bar cables. If the latter are impracticable on account of their great cost, the same design can still be executed with wire cables.

In the introduction to this discourse mention was made of a new suspension bridge at Budapest. The hopes, expressed by Professor Mehrtens, that a wire cable design may be adopted, were not realized. The authorities decided finally in favor of an eye-bar cable. This was done with full knowledge of the greater expense incurred thereby, but the action was justified by the patriotic reasons that all material for an eye bar chain could be manufactured in Hungary, while wire cables had to be imported from other countries. The principal reason, therefore, for adopting eye-bar chains was not because they are better or more economical but merely for benefitting the home industries. Similar reasons, of course, do not exist in this country where the material for either type of bridge will be manufactured by home industries.

From a description of this bridge in the "Zeitschrift" of the Society of German Engineers, Vol. 1900, the writer has gathered some interesting data.

It is stated that the total weight of the bridge is 68.1% more than that of the wire cable design, which even exceeds the result found by the writer in his comparison between the two types of designs, applied to the conditions of the Williamsburg Bridge. The eye-bars are made of ordinary basic high carbon (0.12—0.15%) Martin steel, and the total cost of the chain is stated to be 6¾ cts per lb. If, to this price, 2 cts. are added for the value of nickel, it would be 8¾ cts., which fully corroborates the writer's assumption of 9 cts. a lb. in his estimate of the cost of eye-bar chains made of nickel steel.

The method of making the bars, and the time for making them, is also interesting and significant, as the adopted process differs from the customary methods in this country and as it entails an immense amount of waste. The dimensions of the bars are 18 × 1-in. with 35-in. heads and about 31 ft. long, and each bar was cut out of a solid plate. There were 4,000 bars and the time for making them was limited to 19 months.

Supposing that a similar state of conditions would exist here, and that the contract for either cable or chain would be let, corresponding to the case of the Williamsburg Bridge, six months in advance of the time when it may be supposed that cable erection could begin, the claimed rapidity of erecting an eye-bar chain would be of no avail. A wire cable, with all the imputed delays, would be finished long before half of the eye-bars were even manufactured.

It is also stated that the total cost of the eye bar bridge at Budapest was only 9.6% more than that of the cable design. This comparatively small increase of cost is due to the fact that 12½% import duty would have been added to the cost of wire cables, and also to the fact, as shown by the given weights of the cables and chains, that the unit stress in the chain was assumed to be about twice as large as it ought to be in order to correspond with the same factor of safety in the wire cable.

Of course, all sorts of designs can be made, and with different assumptions different figures can be obtained, but a true comparison between the cost of wire cable bridges and eye-bar chain bridges, on the basis of equal conditions throughout, as carried out for the Williamsburg Bridge, will always result in the same ratio of difference as stated in this article.

SLIP IN A SMALL PLUNGER PUMP was recently investigated by Prof. John Goodman, of Yorkshire College, Leeds, England, and the results were reported in a long paper read Feb. 20 before the Institution of Mechanical Engineers. The test showed that at high speeds, the delivery of the pump was in excess of the displacement, reaching sometimes 150% of the displacement. Under normal conditions of working, however, the delivery was about 94% of the displacement. The tests showed the advantage of air chambers on pump-suction pipes and indicated that the speed of the water through the pump-valve openings should not exceed about 2 ft. per second.

FIRE-BRICK COATED WITH CARBORUNDUM 1-50-in thick is said to resist the highest temperatures reached in industrial furnaces.

A NEW APPLICATION of the mercury vapor lamp has been made by Mr. P. C. Hewitt, whose vacuum-tube rectifier for converting polyphase alternating into direct current was noted in our issue of Jan. 29, 1903. In perfecting his mercury vapor lamp a few years ago Mr. Hewitt noticed that a high potential was required to start current flowing through the lamp, i. e., the mercury vapor had a very high initial resistance until a certain breaking-down potential was applied. After this had broken down the initial resistance, however, a very low voltage will suffice to keep the lamp in operation; about 14 volts is the normal potential difference across the lamp, which remains sensibly constant with varying rate of current flow. In this condition, if the potential impressed upon the lamp should fall below a certain value which is somewhat lower than 14 volts, the original high-resistance condition of the vapor re-establishes itself, and the flow of current is immediately interrupted. This peculiar property of the mercury vapor vacuum tube is ingeniously turned to account in employing the tube as an "interrupter" for impressing successive impulses of high potential upon a circuit in which it is desired to set up oscillations. This is the case in the transmitting apparatus of wireless telegraphy, where it is necessary to establish high-potential oscillations in a wire (usually a vertical air-wire or "antenna") from which electro-magnetic waves are thereby radiated outward. The arrangement of apparatus utilizing the mercury vapor lamp for this purpose is as follows: An alternating-current generator feeds the primary of a raising transformer, the terminals of whose secondary are connected to the two electrodes of the vapor lamp. The lamp is shunted by a circuit containing two condensers; between the condensers is a small coil, one side of which is also connected to earth. This coil is surrounded by a secondary, which is connected to the primary on the side opposite the earth connection. The other end of the secondary leads to the air-wire. When the alternator is revolved by appropriate means, it produces successions of current waves, the potential of which rises from zero to a maximum, falls to a maximum negative value, rises again, etc. These potential waves are repeated, at much higher potential values, by the transformer and by it are impressed upon the lamp. As the voltage rises it charges the condensers until the breaking-down potential of the lamp is reached. At this moment the condensers discharge back through the lamp until their potential is less than the lower critical point of the lamp, at which point the high resistance of the mercury vapor interrupts the current flow. Meanwhile the other side of the two condensers in discharging sends a current impulse through the small primary coil between them; this impulse is greatly multiplied by the secondary connected with the small coil, and thence passes into the air-wire and the ground as an electric oscillation. Evidently one impulse of this kind will originate for each alternation of current in the alternator, and thus a regular and continuous succession of oscillations is set up in the air-wire, whence the corresponding ether waves are radiated outward. The great superiority of this interrupter over those hitherto used in wireless telegraphy is the regularity of the sending impulses, by which a much more powerful and more easily adjusted transmission is secured than has been possible hitherto.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF ILLINOIS.—The College of Engineering has a bill before the State Legislature providing an appropriation of $300,000 with which to increase the equipment and the facilities for instruction. There are now more than 600 students in the college, the attendance having more than doubled in three years. In number of students this college is said to be exceeded by only five similar institutions in the United States.

In the Mechanical Engineering Department, Prof. Breckenridge is making a specialty of a card index (kept strictly up to date) covering some 40 domestic and foreign technical publications in the line of mechanical engineering and railway engineering. The system adopted is an extension of the Dewey decimal classification, and the same system is followed in filing prints, books, cata-

logues, clippings, etc., in this department. Duplicates of the cards are furnished to the Western Society of Engineers, and copies of the groups cards relating to certain subjects or branches are sometimes called for by manufacturers. A pamphlet of 20 pages has been issued giving the detailed classification of subjects.

A pamphlet has been issued by the University in regard to its courses of training for business. These include economics, industry, commerce, languages, law, mechanical technology, etc. The courses are intended as a foundation for a mercantile or business career.

A 50,000-VOLT ELECTRIC POWER TRANSMISSION LINE 65 MILES LONG.

A very instructive paper on "High-Voltage Power Transmission,"* by M. H. Gerry, Jr., Assoc. M. Am. Soc. C. E., was presented at the March 4 meeting of the American Society of Civil Engineers.

The line described in detail by Mr. Gerry is one that has now been in continuous operation for a year delivering a 50,000-volt current at Butte, Montana, from a point near the Canyon Ferry post office on the Missouri River, 65 miles away. This is undoubtedly the highest voltage ever transmitted commercially. It speaks well also for Mr. Gerry's engineering management that the 12,000-volt current, transmitted a distance of 17 miles to Helena, was kept up continuously without a single stoppage for 26 months—a fact brought out in the discussion following the reading of Mr. Gerry's paper.

One of the most interesting points to which attention was called by Mr. Pratt, in commenting upon the engineering features of this work, was that bearing upon the early design of penstocks for the turbines of the power generating plant. When Mr. Gerry took charge of the work the power house was partly finished, and long penstocks had been provided. He found it necessary to remove these penstocks, replacing them with an open forebay, the change costing about $150,000. The reason for making this change was that with the varying load upon the dynamos it is necessary to have a quick acting governor to regulate the gates supplying water to the turbines. With long penstocks, even after a gate has been partly closed by the governor, the water by virtue of its inertia in a long column rushes through the gate with a greater velocity than that merely due to its static head, thus in a measure nullifying the action of the governor. Civil engineers accustomed to designing water power plants for mills have, in some cases, not been aware of the importance of speed regulation for electric service, hence it may be well to quote in full what Mr. Gerry has to say on this subject:

> Next in importance to the form and amount of loading on the station is the question of speed regulation. For many years close speed regulation was thought impossible for water-wheels driving machinery subject to suddenly varying loads; but the difficulties have been overcome, and it has been found that very satisfactory results can be obtained by correct designing, and the use of proper governors to actuate the water-wheel gates. The first consideration is to have such hydraulic design that the water can pass freely to the wheels, and to avoid those arrangements which require a considerable change in the velocity of the water, with varying gate on the wheels; such, for example, as long penstocks having little hydraulic grade. If the design in this particular is bad the regulation will suffer, regardless of the excellence of the governor, as a time element will be introduced in which the water column will be accelerated or retarded, and during which the water-wheels cannot fully respond to the gate opening, on account of the varying effective head. One of the principal reasons leading to the removal of the old penstocks and the construction of the open canal at Canyon Ferry was to obtain better design in this particular, resulting in better speed regulation for the plant. The nearer the design approaches to an absolutely open setting, with the head entirely above the wheels, the better the regulation.

Speaking of the service maintained at 50,000 volts pressure, Mr. Gerry says that lightning, wind, rain and snow have not interfered with the regularity of the service, and that the behavior of the circuit does not differ materially from that of similar circuits at lower voltages, and there are no luminous effects or discharges under normal working conditions.

An interesting fact is that a satisfactory telephone service is maintained on one of the high-tension pole lines, the two telephone wires being only about 6 ft. distant from the nearest high-tension wire.

*Proceedings, Am. Soc. C. E., Vol. XXIX., No. 1, p. 45.

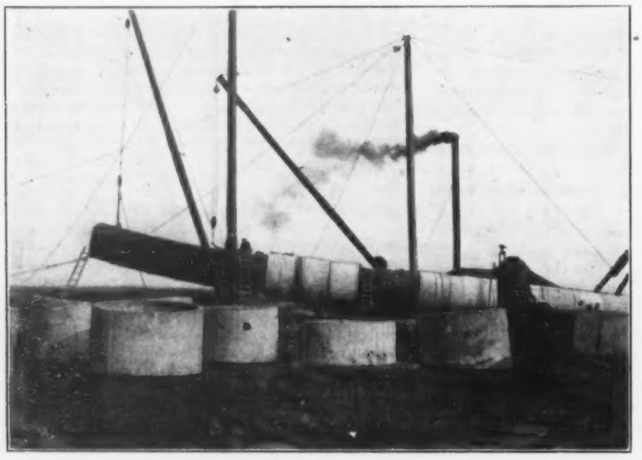


Fig. 1. Riveting Up the Pipe and Putting on the Concrete Jackets.

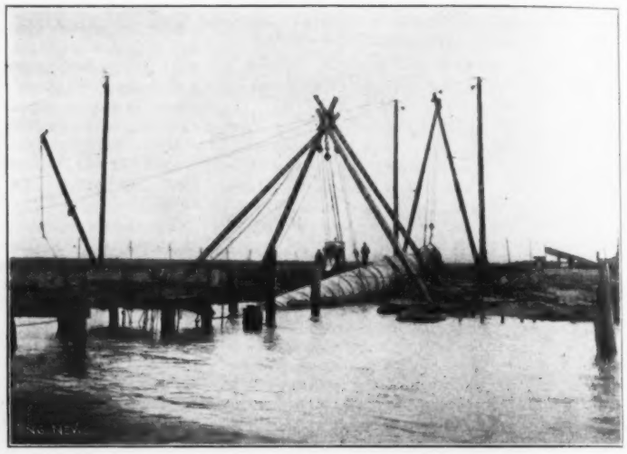


Fig. 2. Hauling the Pipe into the River.

LAYING A 6-FT. CONCRETE-JACKETED RIVETED STEEL PIPE BENEATH THE HACKENSACK RIVER.

LAYING 6-FT. CONCRETE-JACKETED RIVETED STEEL PIPES UNDER THE HACKENSACK AND PASSAIC RIVERS.

A steel pipe line, 6 ft. in diameter and forming a part of the new water supply for Jersey City, N. J., has recently been laid beneath the Hackensack River, near Garfield, and beneath the Passaic River at Lyndhurst, N. J., by the T. A. Gillespie Co., 71 Broadway, New York city. A notable feature of this work was the method used of putting the pipe together on one shore, piece by piece, as it was needed for hauling across under water, with a conical-shaped bulkhead at the outer end, and pulling it across to the other shore, by means of a cable and engine located thereon. This general method of procedure was employed in 1895 by Mr. Clemens Herschel, M. Am. Soc. C. E., 2 Wall St., New York city, for laying seven lines of 16-in. steel pipe across the Passaic River at Belleville, N. J., for the temporary supply of Jersey City; and was advocated by him for use for the 6-ft. pipe just laid. The main across the Hackensack River (Figs. 1 and 2) is laid in 45 ft. of water; the crossing of the Passaic River is about 575 ft. long, and has 28 ft. of water over the pipe. These submerged mains are built up of 11-16-in. plates, with single riveted circular, and double-riveted longitudinal joints. Five lengths of plate are joined to make 32-ft. sections, and the latter are riveted together successively at the shore end and hauled out into the stream.

A departure from the plans advocated by Mr Herschel was made at Lyndhurst and Garfield. It consisted in making the pipe rigid, by encasing the steel main in concrete and grouting. This was effected by making concrete cylinders in advance, 5 ft. in length, 6 ins. thick, and with an inside diameter of 6½ ft. These cylinders were slipped on over the exposed shore ends of the submerged mains, jointed with cement, and run full of grout through a hole left in each section for the purpose. The concrete was designed both for protection, and to give the pipe the necessary weight to keep it from floating, and also from danger of collapse, whenever the water is shut off the pipe line. By the method followed the pipe is kept submerged while being laid, thus putting little or no obstacle in the way of navigation. At Belleville, the pipe was weighted by iron couplings over the screw-joints.

An apparently serious objection to the concrete jacket, as applied at Lyndhurst and Garfield, is that it robs the pipe of that flexibility which is so notable a feature of riveted steel mains, and which Mr. Herschel holds to be particularly advantageous or necessary for this class of submerged work. In fact one may go further and express a fear that in hauling the pipe into position, and after filling it with water, the pipe would be in danger of rupture, but of course this has been taken into consideration by the engineers of the Lyndhurst work.

A description of the seven 16-in. submerged mains at Belleville was published in Engineering News of Dec. 5, 1895. Brief descriptions of the Belleville and Hackensack crossings were given by Mr. Herschel in the Journal of the Association of Engineering Societies for March, 1901. Mr. Edlow W. Harrison is Consulting Engineer to the Jersey City Water Supply Co., the original contractors for the new water supply for Jersey City, and Mr. Garwood Ferris is chief engineering representative in behalf of the city. Mr. W. K. McFarlin is Engineer-in-Charge for the T. A. Gillespie Co.

For the purpose of showing the applicability of this method of submerged work to the laying of tunnels under navigable channels, a party of engineers visited the work at Garfield, Feb. 5, 1903, under the guidance of Mr. Herschel. This pipe has since then been hauled all the way across, and is now (March 4) being connected with the shore ends.

A NEW "AUTOMATIC" LEVEL ROD.

There has recently been patented an "automatic" level rod, in the use of which the ordinary additions and subtractions involved in leveling are not performed, since by proper setting of the rod,

cuts, fills, or elevations are read direct; that is, the rod reading itself is the cut, fill or elevation. Not only are errors reduced to a minimum, since errors of calculation cannot occur, but the field work also is greatly reduced.

An incidental feature of advantage is that, in place of three columns of figures, there is only one column to be copied from the field book into office books. This is well shown by the accompanying Figs. 10 and 11. Fig. 10 shows a common form of profile notes using a Philadelphia rod; while Fig. 11 shows a form of notes, using the automatic level rod. The saving in space is striking.

THE ROD.—As seen in Fig. 1, the rod is telescopic, being composed of two L-shaped pieces, shown in cross-section, Fig. 3, mounted to slide upon one another. Suitable guides and clamps are provided to hold the rod when extended. The rod is graduated both front and back like a Philadelphia rod, and can be used as such; but in addition it has a graduated tape, shown on the side of the rod, Fig. 3. This endless tape is the essential feature of the rod.

A target, T, is provided with a rod level, B, and a vernier. There is another vernier, V, for reading the tape on the side of the rod, and this vernier reads both up and down. Rollers, R, R', r, r', Fig. 2, are provided to carry the endless tape; and the upper roller, R, is mounted in a sliding yoke, Y, that can be raised by a thumbscrew, S, so as to tighten the tape. The tape itself is shown in Fig. 5, and is four times as long as the rod. Occasionally it might be desired to take the tape off the rod and use it as a slope tape in setting slope stakes; so for this purpose the rear face of the tape is graduated, as shown in Fig. 4, the units of graduation being 1½ ft. long to provide for slopes of 1½ to 1. The zeros, E and F, are placed 13 ft. apart, which is one-half the width of the widest roadbed ordinarily encountered. When the tape is off the rod and used as a slope tape it may be shortened so as to bring the zeros closer together by a clip shown in Fig. 6; the distance apart of the zeros being thus made equal to half the road bed width. This, be it noted, is done only when the tape is used off the rod as a slope tape. Ordinarily, however, it would not be desirable to ever remove the tape from the rod, but to use an entirely separate tape for slope staking; in which case the length of the tape on the rod might to advantage be reduced.

The method of using the rod will next be described.

PROFILE LEVELING.—Assume a turning point, T, Fig. 7, which is found to have an elevation 102.0. Then in taking a foresight with the level at K', the reading on the tape will be exactly 2.00. Carry the level to K, set up for back sight. The rodman then raises the tape until the leveler reads exactly what he read on the foresight, namely, 2.00. In a word, the addition of the backsight is done mechanically by moving the tape "grade." Thus, if the turning point elevation were 102.00 and the grade elevation 107.0, Fig. 8, the tape should be set on the rod to read 107.0 — 102.0 = 5.0, as is shown in Fig. 8. Then, wherever the rod is held on the ground the rod-reading is the fill at that station. For cuts the tape is set to read on the opposite side of its zero point so as to read progressively upward. All that remains to be explained is the use of a slope tape in connection with the tape on the rod. In Fig. 8 is shown a 16-ft. roadbed with a 1½ to 1 side slope. A slope tape having its units of graduation 1½ ft. long must therefore be used; and its zero of graduation must come directly under the angle points A, A', that is, 8 ft. from the center stake. Now, all that is required to find the exact position of a slope stake is to move the rod in or out until the rod reading and the reading on the horizontally-held slope tape agree exactly. When that position is found, there must the slope stake be driven. In Fig. 8, it will be seen that the fill is 6 ft. on the right at P, and 2 ft. on the left at Q, at which points slope tape and rod readings coincide. These points are rapidly found without any calculation, and in most cases a hand-level will expedite the work if used instead of a Y-level, while at the same time securing all the accuracy necessary in guiding the contractor.

A somewhat more approximate method of slope staking is shown in Fig. 9, where the only level used is the small target level on the rod. The target level insures having a vertical rod, and by swinging the slope tape up and down until its least reading is found, one secures its reading when the tape is practically horizontal. In this case the tape on the rod is removed entirely and used as the slope tape. The chainman at the center stake holds the numeral on the tape corresponding to the center cut, in this case 5.0; while the rodman moves the rod in or out until a

Grade - 97.50

Sta.	+	H.I.	-	El.	Cut.	Fill.
B.M.				96.31		
	6.42	102.73				
A			7.7	95.0		2.5
B			3.2	99.5	2.0	
T.P.			10.16	92.57		
	1.02	93.59				
C			3.4	90.2		7.3

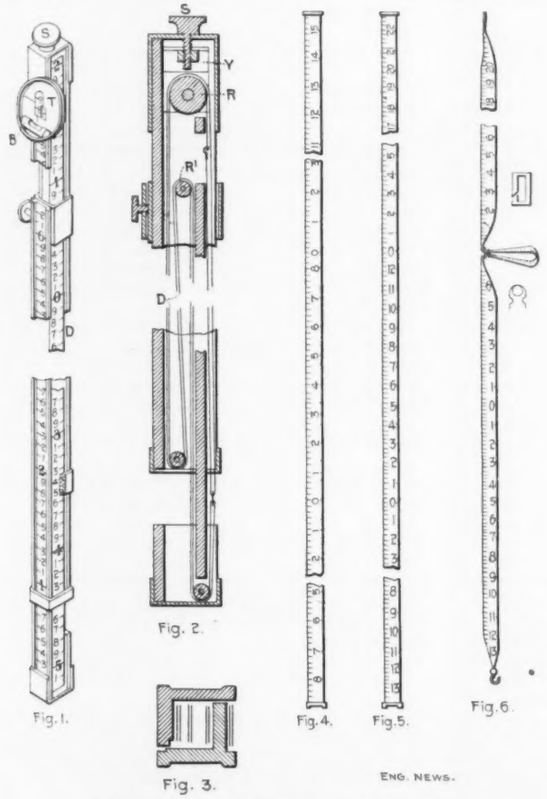
Fig. 10. Form of Profile Notes Used With a Philadelphia Rod.

Grade = 97.50
B.M. = 96.30
R.S. = +1.20

Sta.	Cut.	Fill.
A		2.5
B	2.0	
T.P.		4.96
C		7.3

ENG. NEWS.

Fig. 11. Form of Profile Notes Used With the Automatic Level Rod.



FIGS. 1 TO 6. AUTOMATIC LEVEL ROD.
G. G. Heghinian, Inventor.

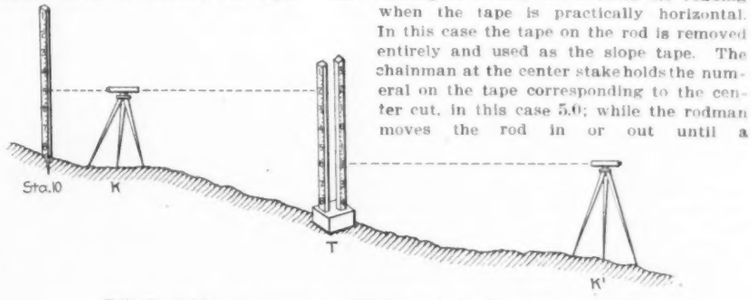


FIG. 7. PROFILE LEVELING WITH AUTOMATIC LEVEL ROD.

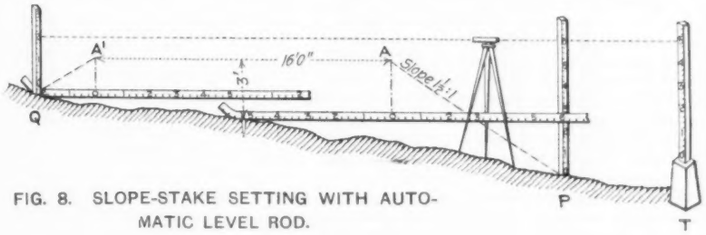


FIG. 8. SLOPE-STAKE SETTING WITH AUTOMATIC LEVEL ROD.

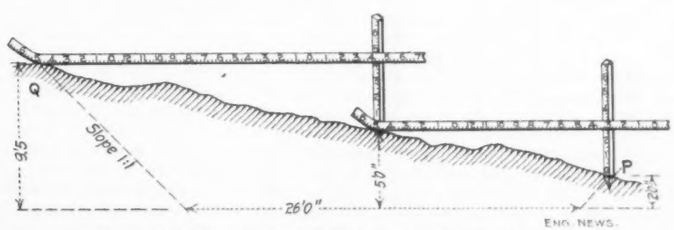


FIG. 9. SLOPE-STAKE SETTING WITHOUT A Y-LEVEL.

SLOPE STAKING.—In setting slope stakes it is generally desirable to set the rod on a T. P., or B. M., but if the ground is comparatively regular, and the profile levels have been carefully checked, the rod may be set on the ground at the center stake, and the tape adjusted there. In either case the principle is the same; the tape is so set that it would read zero if the rod were held on Now, when the rod is held on the ground, as at Sta. 10, the rod reading, 5.0, on the tape gives at once the ground elevation at Sta. 10, or 105.0 ft. So wherever the rod is held the rod reading is the ground elevation.

position, P, is found where the tape and the rod read alike, in this case 3.0—there the slope stake is driven. To find the position of the other slope stake, Q, the chainman, still grasping the tape at the numeral 5, moves out from the center and holds the numeral 5 on the ground. The rodman holding the rod at the center stake and the slope tape horizontal, calls a halt when he notes that the reading on the slope tape and on the rod are identical, in this case 4.5.

The rod, as described, was patented Dec. 30, 1902, by Mr. Garabed Geo. Heghinian, Bureau of Highways, Municipal Bldg., Brooklyn, N. Y.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, - - - - MANAGING EDITOR.
F. P. BURT, - - - - - - - - BUSINESS MANAGER.

M. N. BAKER, CHAS. S. HILL, - - - - - } ASSOCIATE EDITORS.
E. E. R. TRATMAN, F. E. SCHMITT, - - - - }
WM. KENT, H. P. GILLETTE, - - - - -

CHAS. W. REINHARDT, - - - - CHIEF DRAFTSMAN.

ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
J. B. READ, Boston,
ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 10 weeks, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $8.00; Thin Paper Edition, One Year, $6.75. SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 323 means that subscription is paid to the 32d week (that is the issue of Aug. 6) of the year 1903; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The United States Steel Corporation management announced last week its intention to proceed with the plan adopted a year ago, but delayed by litigation, to make a further increase of $50,000,000 in its bonded indebtedness, the money raised to be used in enlarging and improving various plants. We commented on this scheme a year ago; but while there was abundant reason to criticise it then, in the present situation words can hardly be found severe enough to fitly characterize this piece of financiering.

In the announcement of the Board of Directors ordering the plan put into execution, we are told that the improvements to be made with this $50,000,000 will increase the annual productive capacity of the various works by 2,700,000 tons, which "under normal conditions" it is estimated will bring increased net earnings of about $7,000,000 per year, while there will be a saving in cost of manufacture estimated at about $5,000,000. These figures are attractive on their face; but what if buyers could not be found for this 2,700,000 tons of additional product? Statistics show that the increase in iron and steel productive capacity during the past four years has been enormous, and in many lines has gone far past the capacity of the market to absorb it. Everyone recognizes that sooner or later the financial pendulum must swing in the other direction. These are the times when it is the part of sound financiering to reduce obligations, scale down capitalization scrutinize very closely all schemes for expansion and prepare for hard times. So far as the improvements proposed by the Steel Corporation are designed merely to reduce cost of production without increasing capacity there is something to be said for them. The question still unanswered, however, is: Why not pay for these and any other necessary improvement out of the company's overflowing treasury, instead of piling another deck-load of bonds on the already overburdened vessel? Is there any reason for this save the huge commission on the loan which is to go directly into the pockets of the parties in control of the corporation? Certainly this latest action of the Steel Corporation is the most convicting indictment ever framed of Wall St. bankers as managers of industrial corporations.

The advantage of advertising large contracts in sections was recently illustrated afresh at New Orleans. Bids about 4% above the engineers' estimates were received on six sections, but on two sections the estimates were exceeded by 28%. Mr. Geo. G. Earl, General Superintendent of the Sewerage and Water Board, reported that there seemed to be no good reason for these high bids, and accordingly he recommended that they be rejected, but that the others be accepted.

Every now and then some well-meaning correspondent of the daily press proposes to supply New York with water from Lake Champlain, Lake George, or even from one of the Great Lakes. A recent correspondent of the New York "Times" advocates a supply from Lake Champlain and suggests that a pipe line be laid in the towpath of the Champlain Canal from Whitehall to Albany, and "along the river bank in the bed of the" Hudson River from Albany to New York. "The only cost," this correspondent urges, would be "for pipe and labor." Inasmuch as Lake Champlain is at an elevation of but 101 ft. above sea level, we suggest that this gentleman ask some of his engineering friends to estimate for him what the pumping expenses would be to provide pressure for ordinary and high level service in New York, after deducting from the 101 ft. initial head the friction losses in considerably over 200 miles of pipe line.

The relative cost and ease of erection of eye-bar cables for suspension bridges, as compared with wire cables, are questions upon which a lively difference of opinion seems likely to develop in connection with the construction of the Manhattan Bridge now being built across the East River at New York city. The first chief engineer of this bridge, Mr. R. S. Buck, M. Am. Soc. C. E., designed a structure with four wire cables. His successor in charge of the bridge, Mr. Gustav Lindenthal, M. Am. Soc. C. E., materially revised Mr. Buck's plans and in particular substituted four cables composed of eye-bars of forged special steel. Mr. Lindenthal claims for his cable plans increased rapidity of erection and no greater first cost. In these claims he is supported by the Commission of engineers, which was appointed to review the plans, and whose report is published in full in another column of this issue. Set against these opinions are those of Mr. Wilhelm Hildenbrand, M. Am. Soc. C. E., one of the most experienced suspension bridge engineers in the country, and the authorities which he quotes in an article printed elsewhere in this issue. It should be mentioned, perhaps, in view of their simultaneous publication, that Mr. Hildenbrand's article was placed in our hands before the report of the engineer commission had been made public. If Mr. Hildenbrand's contentions are correct, eye-bar cables for the Manhattan Bridge will take longer to erect and will cost more money than will wire cables. These contentions are based upon the assumption that the Williamsburg Bridge and the Manhattan Bridge are closely comparable in span and capacity, and that what is true of one is also substantially true of the other. Mr. Hildenbrand then proceeds to show that, had eye-bar cables been employed on the Williamsburg Bridge instead of the wire cables actually built, that structure would have cost over $3,363,000 more than it actually did cost. The details of Mr. Hildenbrand's argument need not be repeated here, but they are of exceeding interest and should be read by every bridge engineer. Just where the real truth lies between Mr. Hildenbrand's contentions and the claims of the Bridge Commissioner and his supporters will probably require much careful study to determine. The question is one, however, which involves the expenditure of several millions of dollars and is well worthy of careful investigation.

Few American cities can account definitely for more than a small percentage of their water supply. Most of them know more or less closely the number and character of the fixtures supplied and, of course, the metered consumption, if any, is a known quantity; but the division of the supply between public and private uses, the amount lost through leakage of the street mains, and the relative amount consumed in different sections of the city are usually subjects of mere conjecture. On this account, the studies of water consumption and waste in the several municipalities forming the Metropolitan Water District (Boston and vicinity) promise to be of great interest. As recently noted in these columns, the board is installing 42 Venturi meters for the purpose just named. It has just sent a very brief progress report to the Massachusetts legislature, which contains an illuminating experience with water wasted in Stoneham. This town was found to have a daily consumption of about 125 gallons per capita. Little water is used there for manufacturing purposes, and it being evident that the local authorities had overlooked some leakage or waste the board proceeded to locate the same. The report states:

> By a series of experiments the waste was localized and leaks in the street mains were found, by which, with the aid of the local authorities, the average daily consumption was reduced more than one-half.

As the board says, it is not likely that similar waste and leaks prevails throughout the whole district, but we have no doubt that the same results in waste detection and prevention could be achieved with slight expense, and with no serious inconvenience to any honest and well-meaning water consumer.

We print in our department of "Letters to the Editor" this week, a suggestive article on the development of power from river currents. It is true, as our correspondent says, that this source of power is at present practically neglected. It is one of the "great powers of Nature" which engineers have not yet converted to the service of man, except in a few isolated cases with primitive appliances of small size. Evidently in considering the possibilities in this direction the first thing to do is to find out how much energy a running stream contains. Our correspondent presents one method for determining this. We will suggest a second.

Suppose we take a section of the stream of one square foot area. Then if the stream is flowing at a velocity of v ft. per second, there will pass through this section in one minute 60 v cu. ft., or 60×62.5 v lbs. of water. This water has a kinetic energy equal to its weight times $\frac{v^2}{2g}$. That is to say, the height to which it would rise if its impetus in a horizontal direction were all used to raise it vertically would be $\frac{v}{2g}$.

Hence the energy per minute which must have been imparted to the water flowing in a section 1 ft. square at a velocity of v ft. per second is in foot-pounds,

$$(60 \times 62.5 \text{ v}) \times \frac{v^2}{2g} = 58.23 \text{ v}^3.$$

Converting this to horse-power by dividing by 33,000, we have the following formula for the horse-power *required to produce* a current of water of a velocity v and 1 sq. ft. cross-section:

$$\text{HP.} = \frac{58.23 \text{ v}^3}{33{,}000} = .0018 \text{ v}^3 \text{ nearly.}$$

Reference to the letter on this subject in our issue of Jan. 8 shows that the above formula is identical with one there given. That this formula is correct for the energy resident in a running stream will doubtless be generally admitted; but now comes the question, how much of this energy can be extracted from it. Mr. McCullough, in our issue of Jan. 8, claims that 40% of the energy can be utilized in case of a current flowing 80 to 90 ft. per minute. Col. Stewart, in his contribution in this issue, claims that one-third of the power of the stream can be utilized. Our own idea is that the percentage of the energy utiliza-

ble depends on the velocity of the stream, and that a far larger percentage can be utilized from rapid streams than from sluggish streams. It can be readily understood that the water in a swift rapid will exert a powerful effect on moving blades or paddles set to receive its force, but when we come to a river flowing at, say, two to four miles an hour, not only must we handle a large section of the stream to deal with any considerable amount of power; but the problem of extracting power from this water to any considerable extent is a very difficult one.

Whatever the form of power apparatus placed in the current, the tailwater must leave it with practically the same velocity as the headwater enters it, and the net effectual work must be accounted for by a fall of the water in passing through it. That is to say, any such power apparatus must dam up the water to some extent; but when it does this, in the case of any large stream, the effect is to divert the stream to either side of the power-developing apparatus, where it can flow freely without yielding up power.

Nevertheless, the fact that many thousands of horse-power is actually present in the tidal floods flowing past the wharves of great seaboard cities and in the currents of the great rivers flowing by many of our inland cities, is one which has doubtless been too much ignored by engineers and inventors. Developments in electrical transmission and other arts make many things possible now in all branches of engineering that were only dreamed of twenty years ago.

A contemporary says: "Good roads in South Dakota are being constructed by good Indians." This must be a mistake either as to the "Indians" or the locality, or else the old adage is at fault. If the good Indians are really engaged in road construction, they are probably laying gold paving blocks in a better land than South Dakota.

THE CARTER CONTRACTS IN THE LIGHT OF TO DAY.

There is no need to tell the American public that O. M. Carter was guilty of the crime for which he is now serving a sentence in the Leavenworth penitentiary, or that his co-conspirators in defrauding the Government, Greene and Gaynor, richly deserved the punishment which they escaped only by flight to a foreign country and by the refusal of that country to deliver them for extradition.

Public opinion long ago reached its conclusion as to the guilt of these men, but it did so, not on the facts brought forward at the court martial of Carter but on the later developments when Carter's father-in-law refused to act the part of a fence, when the fruits of the fraud were traced directly to Carter's possession and when an array of overwhelming testimony left no room for doubt as to the guilt of the conspirators.

It seems strange, indeed, with our present knowledge, that during the whole period from Carter's first arrest until the final approval of his sentence by President McKinley, Carter was able to bring to his support an enormous amount of political, social and even professional influence. It ought to have been clear enough when Carter was first brought to trial that no honest man could have done the things which he was shown to have done and that the contracts which the Atlantic Contracting Co. was carrying out were let at prices so excessive as to furnish presumptive evidence of wrong doing. And yet a whole array of expert engineers of high standing was found to go on the stand and testify that these prices were reasonable.

It is not our present purpose to cast reproach at these men, most of whom acted, we believe, from mistaken motives of sympathy. In their wish to aid a brother engineer in trouble, they overlooked their higher obligation to their profession and to their country.

We trust and believe that most if not all of these men now see and regret their mistake; but it is proper to call attention to it here; for this testimony in support of Carter, and particularly the attempts made by some of these men to influence public opinion in his favor, had the undoubted effect of confusing the public as to the facts of the case and raising doubts whether the court martial's verdict were not a miscarriage of justice. "If Carter were really guilty," it was currently said, "would these noted engineers and high-minded officers, of unquestioned rectitude and moral character, be willing to testify in his favor? Would such a man as Wayne MacVeagh espouse his cause with such fervor? Would the honored name of Edmunds be attached to a certificate of his innocence of other than merely technical irregularities?"

As we have said above, all doubts in the premises were long since settled by the later developments in the case; but it is not without interest to turn back now and see in the light of present knowledge what Carter and his partners were doing, and what profits they were harvesting at the time when Capt. C. E. Gillette was placed in charge of the Savannah station and uncovered in a few days the whole corrupt business.

The Carter conspiracy has been commonly referred to as the Savannah Harbor frauds and gross corruption in connection with the Savannah work was proved before the court martial. The work on the Savannah river, however, had been practically completed when the frauds were uncovered and most of it had been done more than two years previous to the time the charges were filed so that prosecution for acts in connection with it was barred by the Federal statute of limitations, of which Carter was prompt to take advantage. Further, it was found that the fraudulent conspiracy began in a modest way. It was carried on at first very circumspectly. Prices were not raised so high and work was not so poor that the existence of any combination between the engineer officer and the two contractors could possibly be proved. But as year after year went by and nothing happened to cause uneasiness, the conspirators grew bolder. When in 1896 Congress adopted a plan for the improvement of Cumberland Sound, the entrance to the port of Fernandina, Fla., at an estimated cost of $2,350,000, they saw and seized the opportunity to gather profits on a scale beyond anything they had yet attempted. The work to be done was the building of jetties out in the open water of a roadstead and its location made it far less likely to attract public attention than the work previously done on the Savannah River training walls. The contract was let by Carter to the Atlantic Contracting Co. in the fall of 1896, and the contractors were to receive the following prices for all material placed in the work: First and second class stone, $5.25 per ton; third and fourth class stone, $3.90 and $3.50 per cu. yd.; brush mattresses, $1.10 cts. per sq. yd. In October, 1897, when the frauds were discovered and the contract was annulled, the contractors had placed in the jetties 558,000 sq. yds. of brush mattresses and about 20,000 cu. yds. of fourth-class stone—practically only enough to sink the mattresses. The stone used was light Florida limestone, which was shown by the testimony in Carter's trial to have cost the contractors when placed in the work not over $1.85 cts. per cu. yd. The mattresses were little more than piles of brush, roughly fastened together and costing the contractors, according to testimony given at the trial, probably not over 15 cts. per sq. yd.

On the other hand, Carter brought forward at the trial witnesses who swore that the prices paid the contractors were not excessive and involved no more than a reasonable profit. Every engineer appreciates the fact that it is exceedingly difficult in a court of law to prove that a certain price is excessive and exorbitant, particularly when it relates to the performance of a piece of complicated and unusual work with which people in general are wholly unfamiliar.

At the Carter trial there was the widest disagreement between the witnesses for the opposing sides as to what were fair prices for the stone and for the mattresses used and as to whether or not the work which had been done at Cumberland Sound was good and useful engineering construction. This conflict of testimony, as we have already stated, befogged the issue in the case; and it is therefore of interest now to see what the test of time has developed upon these points which were then in dispute.

On another page of this issue we present a paper describing the recent work of channel improvement at Cumberland Sound. The paper was prepared at our request by Mr. Jas. H. Bacon, M. Am. Soc. C. E., Assistant Engineer, under Capt. Gillette, in charge of the work at Cumberland Sound. It shows not only the marvellous success of the work which is now in progress there but the striking contrast between the cost of the work done under the Carter regime and its cost since it was placed in the hands of Capt. Gillette.

When the Atlantic Contracting Co. ceased work on its contract in 1897 it had received about $575,000 out of the total estimated cost of $2,350,000 for the entire work. Mr. Bacon shows that this work was of practically no value. The piles of brush which were dignified with the title of "multiple mattresses," and for which nearly all the money was spent, were long ago eaten up by the toredo and scattered by the waves and currents.

In 1900, after the work had been at a standstill for three years, it was placed in charge of Capt. Gillette, and the remarkable results obtained since that time are in the highest degree creditable to the energy and engineering ability of this officer. Under the old fraudulent contracts, as noted above, $3.50 per ton was paid for light Florida limestone. The contractors under Capt. Gillette, the firm of Christie, Low & Heyworth, have placed in the jetties 308,300 tons of granite, which is brought a distance of several hundred miles and yet its contract price in the work is only $1.90 to $2.15 per ton, according to the size used. Thus the work is being conducted with such economy that, notwithstanding the half-million dollars and more stolen out of the early appropriations by the Carter conspirators, Capt. Gillette bids fair to finish the entire work of improvement at Cumberland Sound with a total outlay by the Government, including its losses by the Carter frauds, less than the amount originally estimated as the cost of the work by a Board of Engineers.

Up to the time when Capt. Gillette took hold of the work in 1900, the results of the Government's work there since 1880, involving a total expenditure of nearly one and a half million dollars, had been absolutely nil. The entrance to the harbor was not between the partially built jetties at all, but through a gap directly across one of them. Since Capt. Gillette began work two years ago, with the expenditure of little more than Carter and his cronies stole, he has made a harbor entrance at Cumberland Sound with deeper water across the bar than any other port on the South Atlantic Coast. The depth at low tide is now over 25 ft., and it is steadily increasing without dredging.

The prevailing sand drift at this location is from north to south, and it will be seen by a map on another page that the sailing channel is located under the lee of the north jetty, where it is effectually protected from the sand drifting southward and where it is also free from injury from the mass of sand between the jetties. This sand, in fact, is now being steadily eroded and carried off across the incompleted south jetty to be deposited beyond it. Thus, as shown by Mr. Bacon in the table elsewhere in this issue, the jetty construction has already caused the excavation of 3,287,000 cu. yds. of material from between the jetties.

There has been more or less published of late in the way of criticism of the jetty system of harbor improvements; and various nostrums in the field of harbor improvement have been advocated before Congressional committees and have been made prominent in some of the technical journals.

One of the very best answers to the advocates of these nostrums is to show what can be and is being done by standard and well established engineering methods when applied by competent and honest men. When such excellent results are obtained at so moderate a cost as Capt. Gillette has secured at Cumberland Sound, the Government has no need to engage in doubtful experiments with patented schemes of harbor improvement.

LETTERS TO THE EDITOR.

The Briquetting of Fuel.

Sir: The article in your issue of Feb. 12 on "The Briquetting of Flue Dust, Fine Ore and Fuel" is a very interesting resume of the history of the art in America. The present shortage and resulting high prices of coal will without doubt renew the effort to utilize commercially the

mountains of slack, culm and slacked lignite which are now practically worthless.

The briquetting plants of the Fuel Patents Co., referred to in your article, made eggettes for domestic or household use, and mechanically these plants were successful. The failure commercially was due to several conditions which could have been overcome. The plant which was built in Chicago drew its supply of slack from coal yards around the city, and these sweepings of yards and bins contained a large amount of dirt, which did not add to the calorific value of the fuel.

These plants as built required too much attendance. To overcome this, the writer was retained to design an automatic plant, using elevators, conveyors, etc., so that raw materials would be taken in at one end of the building and the finished product delivered into storage bins, cars or wagons at the other end. In this way the labor account could be reduced one-half.

The binder used was pitch or coal tar, usually in proportions of 1 part pitch to 16 parts of slack by weight, so that the binder would cost about 75 cts. per ton at present prices of pitch. While the eggettes made with a pitch binder stood handling, they were by no means smokeless when burnt, and from experience with pitch eggettes the writer believes the proper binder is a small amount of porous cement, which will hold up until the combustible portion of the briquette is burned and then easily disintegrate. Briquettes with a cement composition binder, after they are allowed to set, will stand transportation and exposure to water and frost, and burn with little or no smoke. There is an unlimited market for such fuel for domestic uses and for small power plants which are not equipped for burning buckwheat, slack or dust fuels.

Briquetting plants placed at mines where a large amount of slack or culm is in sight, preferably high in B. T. U., handled by modern conveying machinery and briquetted with a cement binder, would prove commercial successes, as they have done abroad, and would utilize enormous quantities of waste.

R. L. Gifford.

Manhattan Building, Chicago, Feb. 18, 1903.

Is Second-Foot a Proper Substitute for Feet Per Second?

Sir: I note in the "Proceedings of the American Society of Civil Engineers" for September, 1900, p. 937, in a discussion on irrigation studies by Prof. Mansfield Merriman, his objection to the term "second-foot" as an abbreviation for cubic feet per second. I think that many others will agree with him that this is not a well-chosen abbreviation, and yet it has heretofore seemed the best, since it has to many seemed desirable to abbreviate the longer expression.

In this connection I desire to call the attention of members of the profession to the fact that the British engineers in India adopted something over five years ago the word "cusec." This is still more brief and to my mind more suggestive. It is to be found throughout all of the recent publications of the British Indian engineering departments. I think that those who are interested in this matter will be glad to note this new word, and perhaps it may be deemed by some worthy of consideration and discussion, with a view to indicating its adoption, or otherwise, in this country. Very truly yours,

H. M. Wilson.

U. S. Geological Survey, Washington, D. C.,
Feb. 25, 1903.

Some Common Objections to the Use of Spiral Curves in Railway Location.

Sir: No doubt any railway engineer will admit that once properly laid, an easement curve makes better and smoother riding track. It is certainly foolish for engineers to split hairs in carefully lining up the curves when they know full well that the trackmen will put in a kink near the ends in order that the mistake of the engineer may be partially rectified by a makeshift curve of their own. Outside of the horror of the practical engineer for the Greek letters and calculus, the following imaginary objections may prevent his use of such curves:

(1) They involve a loss of time and labor on location.

(2) They are not of sufficient flexibility to allow the engineer to use any offset or length of spiral he pleases; or to locate any point of the spiral with equal facility, thereby preventing the continuance of his even stations and plusses.

(3) They require an extra book of tables and long-winded demonstrations.

The first objection is that of a lazy man, for none other would consider the loss of a few minutes against the benefit of the road. Moreover, their use really facilitates location in rough country as far as its projection goes.

The second objection is wholly without foundation, as we shall show, and as for the last one, an engineer can in a half hour insert all the tables he needs between the columns of squares and cubes, contained in any regular field-book.

Any transition curve by whatever name disguised is, for the practical man, a cubic parabola. We will adopt the following nomenclature:

D = degree of curve at any point of spiral, and varying directly as the distance on the spiral.
r = rate of change of D per station.
L = length of spiral in stations.
Δ = angle between main tangent and tangent at any point of spiral.
d = deflection to any point.
S = shift, or amount by which the original circular curve is shifted toward the center.
T = total tangent distance.
x and y = co-ordinates of any point from point of spiral.

The equations for the curve are:

$$y \text{ (in feet)} = \frac{4\,Sx^3}{100\,L^2}, \text{ and } S \text{ (in feet)} = \frac{100\,L^2}{24\,R}.$$

From these, if r = 1, it is easy to deduce the rule which makes the calculation of the deflections so easy, viz: For r = 1 the deflection in minutes equals the square of the distance in feet divided by 1,000. A mental multiplication by the value of r is easily made. In ordinary cases the engineer will use his judgment as to the length of spiral required to attain the superelevation of the outer rail at the P. C. C.; in other cases his shift may be fixed and his value of r and L have to be calculated.

The following formulas are given, of which 1, 4, 6 and 7 are the only ones usually needed:

(1) $D = r\,L.$

(2) $r = 0.2697 \sqrt{\frac{D^2}{S}}$

(3) $L = 3.7082 \sqrt{\frac{S}{D}}.$

(4) $d \text{ (in minutes)} = \frac{L^2 \text{ (reduced to feet)}}{1{,}000}.$

(5) $\Delta = 3\,d.$

(6) $S = 0.0727\,r\,L^2.$

(7) $T = 50\,L + R \tan \frac{1}{2}\,I + [S \tan \frac{1}{2}\,I - .000125\,r^2\,L^5]$

(8) $y = 0.2909\,r\,L^3.$

The term $.000125\,r^2\,L^5$ was taken from an article by Professor Talbot some ten years ago. In his table of squares, cubes, etc., the writer has inserted values of S and of $.000125\,r^2\,L^5$ opposite the proper values of L. They may be made out for each foot up to 300 (as long as needed) or to each 10 feet and intermediate values interpolated.

Suppose we have I = 48°, D = 6°, station of P. I. = 9 + 50. If we use r = 3 our length of spiral is $\frac{D}{r}$ = 2 stations. Our tables give us S = 0.581 × 3 = 1.74 as the shift. The small correction × r^2 only amounts in this case to .04 and will be dropped. From eq. (7) our tangent is seen to be 526.2. ∴ P. S. is at 4 + 23.8. If we desire the deflection at 5 + 50 our table of squares gives the square of 126 as 15876, and by pointing off three figures and multiplying by 3 we obtain 0° — 48′ as the deflection. On reaching our P. C. C. at 6 + 23.8 we have used up 6° of central angle, hence we will have 36° of 6° curve. Setting up on P. C. C. we turn twice the deflection (in this case 4°) to get on tangent. The whole process is like cross-sectioning, which is "more easily done than described."

In as simple a way the branches of a compound curve may be connected by a spiral if desired.

Yours truly, H. E. Abbott.

Nutley, N. J., Jan. 22, 1903.

Effect of Long Lines of Hose and Small Mains on Fire Streams.

Sir: In your issue of July 3, 1902, you published a "Diagram of Fire Streams," prepared by me, founded on experiments by John R. Freeman, combined with my own experiments on friction losses in hose. My own experiments were made principally to demonstrate the loss arising from the use of long lines of hose, but as the objections to long lines of hose apply in a lesser degree to long lines of small mains I have added to my former chart a compilation for small mains from Weston's "Tables Showing Loss of Head Due to Friction in Pipes." These friction losses I have given in pounds instead of in feet head, as given by Mr. Weston, as I think it more convenient (at least for direct pressure systems) in arriving at the total number of pounds pressure to be maintained by the forcing pumps. It is hardly necessary to say that whatever the number of fire streams may be, the final measure of friction in the mains is due to the total volume of water delivered, to which must be added the additional friction due to length of hose and volume of stream thrown.

I have added to the former chart a curve for 1-in. ring or ⅞-in. smooth nozzle, a table of friction losses in 2½-in. hose, and the horizontal distance of streams thrown.

The table of friction losses is of special value in direct pressure systems where the forcing pumps have not only to overcome the friction in the hose, but also in the water mains. The chart gives a ready and easy mode of ascertaining what pressure must be maintained by the pumps, and also the gain due to use of larger mains.

S. A. Charles, Superintendent Water-Works.

Lexington, Ky., Jan. 24, 1903.

Friction Head in 4 to 6-in. Clean Cast-Iron Pipe.
(Recomputed from Weston.)

Gallons per minute.	Pounds lost in friction per 1,000 ft.* Size of main, ins. 4	6	8	10	12	16
50	.82	.1	.0	.0	.....	.....
100	3.3	.4	.1	.0	.....	.....
150	7.4	.9	.2	.0	.....	.....
200	13.1	1.6	.4	.1	.....	.....
250	20.5	2.5	.6	.2	.1	.....
300	29.5	3.6	.8	.3	.12	.....
350	40.2	4.9	1.1	.4	.14	.....
400	52.5	6.4	1.5	.5	.19	.....
450	66.4	8.2	1.9	.6	.2	.....
500	82.0	10.1	2.3	.7	.3	.....
550	99.2	12.2	2.8	.9	.35	.....
600	118.1	14.5	3.3	1.1	.4	.1
650	138.6	17.0	3.9	1.3	.5	.11
700	160.7	19.7	4.5	1.5	.6	.12
750	184.5	22.7	5.2	1.7	.7	.15
800	209.9	25.8	5.9	1.9	.75	.17
850	237.0	29.1	6.7	2.1	.85	.20
900	265.7	32.6	7.5	2.4	.9	.22
950	296.0	36.3	8.3	2.7	1.1	.24
1,000	328.0	40.3	9.2	3.0	1.2	.28
1,100	396.9	48.7	11.2	3.6	1.4	.33
1,200	472.3	58.0	13.3	4.3	1.7	.39
1,300	554.4	68.1	15.6	5.0	2.0	.46
1,400	642.8	79.0	18.1	5.8	2.3	.50
1,500	738.0	90.6	20.7	6.6	2.6	.60
1,600	.....	103.1	23.6	7.6	3.0	.70
1,700	.....	.....	26.6	8.5	3.4	.80
1,800	.....	.....	29.9	9.6	3.8	.91
1,900	.....	.....	33.3	10.7	4.2	1.01
2,000	.....	.....	36.9	11.8	4.7	1.1
2,500	.....	.....	57.6	18.5	7.3	1.7
3,000	.....	.....	....	26.6	10.5	2.4
4,000	.....	.....	....	....	18.7	4.4

*For distances other than 1,000 ft. take proportional amount.

(The original diagram was submitted to the American Water-Works Association, at its meeting in June, 1902, and may be found in the "Proceedings" of that association, as well as in the issue of this journal already named. Mr. Freeman's original figures will be found in his "Experiments Relating to Fire-Streams" (Trans. Am. Soc. C. E., Vol. XXI., p. 303). We reprint Mr. Charles' new table here, which can be used in connection with the diagram published as already stated. The friction losses given are for clean cast-iron pipe. The hose used by Mr. Charles in his experiments was 2½-in. rubber-lined, not new, but in good condition.—Ed.)

A Defence of Electric Iron Reduction.

Sir: I have noticed in Engineering News of Jan. 8, 1903, an article entitled "An Attempted Defence of the Electric Smelting of Iron Ores."

The third paragraph of the said article, relative to my process for the manufacture of steel, exploited by the Compagnie Electro-thermique Keller, Leleux & Cie, with office at 3 Rue Vignon, Paris, is, speaking in the same terms as the writer of the article, written either in ignorance or with intention to deceive.

It is stated that the 2,800 KW.-hours given as the electric energy necessary for the manufacture of one ton of steel by my process is equivalent to 104 HP.-days. Following the most elementary rudiments (of arithmetic) we calculate that:

$$2{,}800 \text{ KW.-hours} = 3{,}808 \text{ HP.-hours, or: } \frac{3{,}808}{24} = 158.7 \text{ HP.-days of 24 hours.}$$

This is shown as 104 HP.-days in the article in question, and it is upon this gross error that the author bases his malicious conclusions. Further comment hardly seems necessary.

A second error is committed in the calculation cited. He does not speak of the metric ton of 1,015 kilos., but of the French ton of 1,000 kilos., so that the energy as necessary with my process for the production of one ton metric is therefore found to be:

$$158.7 \times 1{,}015 = 161 \text{ HP.-days of 24 hours.}$$

The author of the article declares that he personally has shown that the energy theoretically necessary for the production of one ton (of 2,000 lbs.) of iron is 131 HP.-days of 24 hours, or 146.7 HP.-days per metric ton of 1,015 kilos.

The figures as supplied to my process, as I have already said, are 161 HP.-days, which implies that the output of the furnace which I employ referred to the heat developed is:

$$\frac{146.7}{161} = 91\% \text{ approximately,}$$

a reasonable figure, and possible for a good electric furnace.

The writer of the article can therefore be confuted by his own calculations. It would have been easy, with greater care in his statements and figures, to have avoided the necessity for this lesson in elementary arithmetic, as well as in correction.

I ask you to be good enough to insert this protest in the next issue of your journal.

Very sincerely, Keller.

Directing Technical Engineer of Keller, Leleux & Co.

3 Rue Vignon, Paris, Jan. 30, 1903.

[The foregoing is a translation from the French forwarded to us by Mr. Peter McN. Bennie, foreign representative of the Acheson Graphite Co., of Niagara Falls, N. Y.

We find that our correspondent is right in saying that we have erred in ascribing to his furnace an output of a ton of iron by an expenditure of only 104 E. HP.-days.

We had confused his furnace with another French furnace also cited by Mr. A. J. Rossi in his serial paper that appeared in "Iron Age" of Nov. 20 and Dec. 11, 1902; and in ridiculing the absurdity of such a claim of efficiency we did our correspondent the injustice of ascribing the claim to his furnace.

It will be noted that our correspondent's records actually substantiate the claim which we made in our issue of May 2, 1901, that it would be impossible to produce a ton (2,000 lbs.) of electric pig iron with an expenditure of energy less than 131 HP.-days.—Ed.]

Artificial Underground Water Supplies.

Sir: The method of developing an underground water supply employed by Mr. J. Gustaf Richert, of Stockholm, Sweden, and described in your issue of Jan. 8, 1903, was presented to me several months ago, and I must say the ideas ideas therein set forth are extremely attractive. Of course, it is evident that the principle can only be applied in particular cases, but innumerable situations exist in which the conditions must be favorable for this artificial infiltration, and I have in mind now several places where it is the intention to introduce the method into my own designs.

Two important features of this system are the possibility afforded by it of pumping water on a large scale from deep wells, and the permanency of successful operation of these wells even if the ground water level is maintained. It is always a great advantage to be able to pump the water at suction distance instead of by means of a deep-well pumping apparatus or by air-lift methods. Where water can be obtained at suction distance, and the greatest draft upon the ground water is desired, there is one of two methods to be adopted: Sink one or more large wells from 5 to 20 ft. in diameter, or a system of gang wells from 2 to 10 ins. in diameter. If the material at the bottom of the well is composed of sand and fine gravel, the gang-well system requires strainers which sooner or later clog and obstruct the flow; and even if this is not the case, the fine sand eventually collects near the bottom of the well and produces the same effect; besides, there is always more or less trouble due to sand rising in the pumps. The method of open wells to a large extent obviates these difficulties. I have found that sand as fine as ordinary bar sand, used for building purposes, will not rise, providing the upward velocity of water through the same is not greater than 2½ ft. per min. If sand is much finer than this it is difficult to obtain much water from wells. Given, then, a sufficient area of land adjoining a good depth of not too fine sand, and adjoining a stream or river containing a sufficient amount of contaminated water, but otherwise of proper quality, probably the most practical and economical means of obtaining the water would be to sink a series of wells, say 4½ ft. in diameter, with open bottoms, located at the most favorable depth in the water-bearing strata. These caissons should be made of ¼-in. mild steel, riveted together with straps on the inside, and having the rivet heads countersunk on the outside, so as to present a smooth outer surface. These cylinders can be sunk in sections by excavating all material from the inside and riveting on the next section as fast as the top of the preceding one is sunk nearly to the surface. Often this can be done dry without danger of caving or rising of sand inside of the cylinder. Where the operation, however, is in very fine wet sand in the nature of quicksand, it will be best to keep the inside of the cylinder full of water, use a centrifugal sand pump, and in any case load the cylinder on top with eight or ten tons weight. Usually a 3-in. centrifugal pump, located on the surface, is sufficient in size to sink the well at a satisfactory speed. Where the sand is of uniform quality, about the size of ordinary bar sand, a well 4½ ft. in diameter is good for about 300 gallons per minute without danger of raising the sand.

This system of wells can be used successfully until the good effects of the natural infiltration are exhausted, after which the principle of artificial infiltration, as described by Mr. Richert, can be introduced.

The subject, as far as we have any accurate knowledge in this country, is in a speculative condition, but the advantages of the open-cylinder wells have been proven conclusively at El Paso, Tex., where the water company had endless trouble with gang wells until they introduced this method.

If the material contains no large boulders or ledge rock, I see no reason why the wells cannot be sunk to a great depth by this method of keeping the wells full of water and pumping the sand from the inside. As the sand is pumped out it is removed and the water allowed to flow back into cylinder. To strengthen the cylinders against collapse due to great depth, angle or T-irons can be riveted around the inside. If the material becomes solidified and difficult to remove, a ½-in. water jet directed against the bottom of the well will effectively loosen the material. Any centrifugal pump will pump sand, but the sand-centrifugal pump will last far longer under this service. The quantity of sand pumped is usually over 6% of the water pumped.

Since writing the above, the writer has had experience which fully confirms the conclusions in regard to sinking by the sand-pump method under water. At Millville, N. J., a well having an internal diameter of 8 ft. was sunk along the flats on the east shore of the Maurice River. The material passed through proved to be varying grades of fine and coarse water-bearing sand. The depth of well was specified to be 36 ft. A wooden curb was constructed and the brick wall built thereon. The method adopted by the contractor was to build up the brickwork about 6 ft. above the surface, add weight to the top, and excavate from within, undermining the curb. This method proved satisfactory down to a depth of 20 ft., at which very fine sand was encountered containing a large amount of water. Two No. 5 pulsometer pumps were required, but with all the efforts of the contractor he was unable to lower the well much below this point. Whenever he was able to get the water out and attempt to excavate, the sand would come in with a rush and fill up the well for 5 or 6 ft. from the bottom. It was then that the sand-centrifugal pump was introduced, and after a few weeks the full depth was reached. It was originally intended to put in a concrete bottom, but knowing that it would be impossible to pump out the well, it was decided to have the bottom put in by a diver. The design for this bottom consisted of 3 × 10-in. yellow pine timbers laid on their edges, and supported underneath the bottom of the brickwork against the upward pressure. To make the bottom perfectly tight, a second flooring, consisting of 1-in. boards, was nailed to this timber bottom.

J. W. Ledoux,
Chief Engineer, American Pipe Mfg. Co
112 N. Broad St., Philadelphia, Pa., Feb. 6, 1903.

The Utilization of the Power of Rivers.

Sir: As water power is cheaper, cleaner and safer than steam and we have learned how to transmit it over the hills and far away, and nearly all waterfalls near "anywhere" are now taken up, men are beginning to turn to the current of rapid rivers as a source of power.

I have a habit of writing an article on this subject every twenty years. My first article appeared in a periodical long since extinct; my second was an editorial in Engineering News in 1882 (July 29), entitled "Cheap Motive Power." My article for 1902 is this (Dec. 23). My article in 1922 will probably be largely retrospective, for I assume that by that time factories, boats, railway trains, irrigation pumps, etc., requiring millions of horse-power, will be operated by power taken directly from the river without building dams or canals. The river itself is a power canal already cut.

Memphis, Tenn., is the best point for utilizing Mississippi River power. A brief narration of my experience there may encourage progressive men. I had a habit of going there to pester the people on the subject of river power every fifteen years, and one citizen would say to another, "The buzzer has arrived." "Which buzzer; the seventeen-year locust or the fifteen-year river-motor man?" On my first visit in 1855 all refused to go to the river to see my model unless I would pay for drinks, so it remained unseen. In 1870 I called again. Was more successful—two "niggers" came and looked at the machine. When I dropped in in 1885 was still more successful—three niggers and one leading citizen came and gazed upon the motor. On my visit in 1890 eight or ten leading citizens assembled to watch the thing go round. I was progressing. I was arousing the people and there was no telling what success might have been mine in fifteen, thirty or forty-five years more. For forty-five years I had been butting against the stone wall of Ignorance; forty-five years I had been patiently knocking at the door of Incredulity; forty-five years I had preached to the dull, cold ear of Doubt and tired the people out. The prospect was now garlanded with flowers. Unappreciation was sinking down behind; Success was looming up before.

But alas! I found that my preaching, which had so often tired others, had finally tired myself. So I said to younger men: "I am too well known; people are beginning to put on ear-muffs in summer when they see me coming to talk river power, but some are awakened; go forth and preach river power to all who will listen without being paid for their time."

In this country a number of river motors are now in use upon the Grand, Green and Snake rivers in a small way. At Vienna, Austria, ten or twelve small flour mills upon the Prater Ufer are run by river-current wheels—the power transmitted to shore by wire rope.

The use of river power has been retarded by two errors. The first was the use of the undershot wheel instead of the screw. A small screw yields as much power as a large wheel because all its paddles or blades are always in action. Only a small part of the wheel is in the water and that part is receding from the current, hence it cannot receive the current's full force. The screw blade does not recede, but gets the full pressure of the stream. The advantage which the wheel has in its paddles being more nearly at right angles to the direction of the current is a slight one. We see on steam vessels how a small screw does the work of a large wheel. On a steamship, however, the question of paddle-wheel or screw is unimportant, as far as cost is concerned, for that is a trifle compared to the rest of the structure. But on a small motor-boat, the office of which is to support nothing but wheels, and as many, or as large, as it can sustain, it is the paramount consideration, for the boat that will support only a 10-HP. wheel will sustain an 80-HP. or 100-HP. screw or group of screws. Yet so far, astonishing as it may seem, all using the free-stream for power use the paddle-wheel, because they don't understand the screw. It requires about 50 sq. ft. of paddle surface on a paddle-wheel to take 1 HP. from a river whose force is 1 HP. per sq. ft. of transverse section; with a screw it requires only about 3 sq. ft.

If this undershot wheel—of all forms of water motors the most inefficient—can and does in a hundred places furnish power cheaper than steam and when working in currents of only three to four miles per hour, it is easy to see how cheaply power will be obtained when men place screw motors in currents ten to one hundred times as powerful. As the power of a running stream for any given area of transverse section increases as the cubes of the velocities, a 12-mile current yields 64 times as much power as a current of three miles per hour.

Another advantage in the screw is that it has, on account of its small diameter, a more rapid revolution than the wheel. This saves one set of gears or permits smaller gears if only one set is used. Besides the screw can work under water, an important consideration in rivers carrying ice and drift. Again, screws can be assembled in groups or ranks upon long arms projecting from the sides of a boat, and the power of many can be transmitted to one shaft.

The second error in the use of river power was avoiding the swiftest places in rivers on the assumption that it would be too difficult to hold motors there. But the swifter the current the easier to hold, for a given power, because power is the product of pressure multiplied by speed; hence the swifter the current the less pressure required, and therefore the less chain needed to hold motors. Suppose we want to take 1,000 HP. from a river. In a current of 20 miles per hour only one-tenth as much pressure would be required as in a 2-mile current, because the speed is ten times as great. And as we would obtain the required pressure with 1-1,000 as much blade surface in the 20-mile current, our total motor-weight would be only 1-100 as much and the motor boat would be 1-50 as large. We would require a boat of 20 tons capacity in the 20-mile current, and one of 1,000 tons capacity in the 2-mile current. As the pressure per sq. ft. of transverse section is 100 times as great in the 20-mile current as in the 2-mile, the small boat (the hull considered alone) would receive about twice as much pressure as the large one. But the total pressure on boat and motor would be five times as great in the 2-mile current as in the 20-mile. Yet among all the river motors in use, not one is in a current of high velocity. Another reason for placing river motors in rapids instead of in slower places is that rapids do not freeze over and the ice that passes is soon broken small in the rapids, except far north, where ice is very heavy.

Strange as it may seem, many engineers deny that the power of a running stream increases as the cubes of the velocities, although the rule is laid down in many engineering works and a few moments' reflection shows the truth of it; for if the pressure of flowing water increases as the square of the velocity, the power yielded must increase as the cube. If the pressure of a 10-mile current is four times as great as that of a 5-mile (which is a fact that almost everybody knows, and which is easily proved with a small piece of board held in a stream at different distances from shore), the power yielded must be eight times as great, because power is the product of pressure multiplied by velocity, and four times the pressure multiplied by twice the velocity gives eight times the power.

Currents of 10, 15 and 20 miles per hour are found in the rapids of many rivers. The Niagara rapids, both above and below the falls attain a velocity of 30 miles; the Johnstown flood had a velocity of 72 miles per hour. A screw of 16 ft. diameter (size of a large windmill) would have 160 sq. ft. of blade surface and would yield in a 20-mile current, if made strong enough, about 1,600 HP.; in a 72-mile current about 70,000 HP.; in a 2-mile current, 1½ HP. Not many rivers are deep enough in low water for 16-ft. screws. Use assemblages of smaller ones.

In rivers of slight range (little variation of surface level) motors may be arranged on arms projecting from walls or piling, instead of being placed on boats. In those parts of rivers which freeze over, motors placed upon boats or rafts must of course be removed to harbor before the break-up. But they can work in a frozen river (under a frozen surface).

I have tested many kinds of river-current motors, here and abroad; rigid and feathering-float wheels, screws,

crank-shaft motors, endless chains of paddles and endless chains of coned-spools. The screw yields the most power per dollar of cost and is most easily grouped and most easily handled.

The simplest rule I can give for calculating, before building, what power a screw will yield in a river current is this: Get the velocity of the current from floating chips or otherwise. Say ten miles per hour, 14.6 ft. per second. The square of the velocity in feet per second = the pressure in pounds per sq. ft., 14.6 × 14.6 = 213 lbs. pressure per sq. ft. Multiply the pressure by the velocity in feet per minute, 213 × 880, and we get 187,440 ft.-lbs. of power. Divide 187,440 by 33,000 (ft.-lbs. per horse-power minute) and we get nearly 6 HP. per sq. ft. of transverse section of the river, as the power of the stream. Divide by 3 and we get about 2 HP. as the yield of each sq. ft. of blade upon a screw placed in that current.

A cheap screw-wheel may be made of a cut off the end of a log for a hub, into which insert four posts of iron or oak; the up-stream face of the posts to present an angle of 22½° to the current. Bolt pieces of plank, with their ends beveled to an edge, transversely upon the posts to form the blades.

For use in a current of say 3½ miles per hour, the ordinary windmill wheel is strong enough. One 8-ft. in diameter can be bought (the wheel alone) for $15. It will yield in such a current nearly 2 HP., and working steadily night and day seven days per week will do as much work as five large horses.

The ordinary boat propeller makes a good river-motor in currents of high velocity, say 15 miles per hour, but it is cheaper to use a straight-face plank blade screw. Its efficiency is a little less than the curved blade, but this can be compensated for by making the wooden screw a trifle larger.

When one wishes, in high water, to keep the power down to the low-water yield, the screws may be raised partly out of the water, or part of the group allowed to run free, or the motors drawn nearer shore.

As there are no canals, penstocks, etc., to cut or build when utilizing the free-stream, power can be taken (if the current has a high velocity) much cheaper than from a waterfall; and when one large installation of river motors is placed in a current of high velocity widespread interest will be aroused and river motors will doubtless come rapidly into use.

To one who has tested river power it seems the strangest thing in the history of material development that the wind, which half the time is ineffective and nearly always feeble, came into world-wide use before the river, which runs constantly, day and night, and is much more powerful and tractable.

Coal becomes dearer and waterfalls become monopolies. But an entire river is too much for one company to swallow.

In the rivers coursing to the sea are millions of horse-power daily running to waste; we do not appreciate the rolling river because it is so near and has been here so long; had it commenced flowing but to-day we would hasten to harness it. The running stream is an endless driving-belt reeled out by nature from the hollow of her hand. River motors placed in gear with it revolve till worn away. They enslave the giant of the raging river, chain him to all tasks and make of him a patient drudge as long as June is leafy, as long as waters flow. He works days without murmur, nights without sleep, and Sundays without sin, with nature for his only driver.

Sylvester Stewart.

Oakland, Cal., Dec. 23, 1902.

(While inclined to agree with our correspondent that there is an unworked field for the development of power by the utilization of river currents, we fear that he overestimates the power which may be derived from this source. We have discussed the subject further on our editorial pages. —Ed.)

The Use of Decimals with English Units of Measurement.

Sir: The many articles which you have recently published, discussing the advisability of adopting the "Metric System" as "*the* legal standard of weights and measures" in the United States, are very interesting. However, careful reading of these letters forces me to the conclusion that the advocates of the metric system are possessed of the idea that only by the metric system can we have a decimal system of weights and measures; overlooking the possibility of adopting decimal subdivisions and multiples of our present units.

Civil engineers engaged in railway work have already adopted a decimal system of measurement, based upon the foot as a unit, and we who use it find that it works exceptionally well. I see no reason why a decimal system of weights, based on the pound as a unit, would not work equally well. One-tenth and one-hundredth of a pound for small quantities, and a decimal ton of 1,000 lbs. for large ones, would not materially add to the figures required at present for expressing weights.

The fact that all city subdivisions, land subdivisions, and practically all measurements of anything, for record or of permanence, in the United States, are made in the system of which the foot is the unit, should constitute an insurmountable obstacle to the changing of that unit.

The letter from Mr. Robinson, published in your issue of Dec. 25, was particularly interesting to me, from the fact that Mr. Robinson is an engineer of mature years, and one who has had ample experience with both the systems that he compares. In a letter in the Feb. 5 issue, Mr. Miles characterizes Mr. Robinson's letter as a boomerang, in that it points out the difficulty of converting measurements from one system to the other. It is therefore evident that Mr. Corthell's letter in your issue of Feb. 5 is also a boomerang, for he points out that "it is almost impossible to do professional work in countries outside of the United States and Great Britain, etc.," meaning, of course, on account of the different systems.

Since all records and measurements in the United States are in the system based upon the foot, and since it is so difficult to convert from one system to the other, is it treasonable to ask if the great advantages to be gained by the use of the metric system are for the people in the United States or for those on the outside?

If the United States standards of machinery and manufactured products differ from those of other countries would it change our standards if we should measure them in some other unit than the one now used? For instance, would the standard gage of a railway track in the United States be any wider if measured in meters and fractions than in feet and fractions?

It appears to me that if the standards of manufactured products in the United States differ in size from the requirements of those countries using the metric system, then manufacturers wishing to cater to that trade will have to continue to make special sizes for those countries whether measured by one system or the other.

A few months' work among the old vara measured "Spanish grants" of Southern Texas was sufficient to convince me of the undesirability of changing a unit of measurement; but I do think it would be desirable to build up a decimal system, so far as it is possible, upon our present most common units as a basis.

Yours truly, C. W. Baldrige.

Winona, Minn., Feb. 22, 1903.

The Standard Yard.

Sir: In his reply to the opponents of the metric system Mr. A. G. Webster, in your issue of Jan. 29, asks if any one can tell him how many copies of the English yard there are, who has them and how exact they are. He could obtain this information from the Standards Office, Old Palace Yard, Westminster, London, where the British standards are deposited. In the United States the yard originally was the length between the 27th and 63d ins. marked on a Troughton 82-in. brass scale deposited at Washington, and this was supplemented by a copy (No. 11) of the Imperial standard yard of 1855, which was presented to the United States government by the British government in that year. The standard yard of 1496 is still in existence, and copies of the present standard, which has been accurately derived from this, are deposited in the Houses of Parliament, the Royal Observatory, the Royal Mint and the Royal Society.

Yours faithfully, Bennett H. Brough.

28 Victoria St., London, Feb. 20, 1903.

Experience with the Metric System on Railway Construction.

Sir: As an engineer with nearly ten years' experience with the metric system on railroad work I wish to object most emphatically to Mr. A. S. Robinson's statement in regard to the numbering of stakes on railroad location using the metric system.

The system he speaks of, numbering the stakes from 0, 1, 2, 3, 4, etc., for each 20-meter station may have been used on some road with which he was connected, but the general practice is, starting at 0, to number the stations 2, 4, 6, 8, etc., so that the addition of a zero gives the number of meters from the starting point.

The extravagant statement he also makes in regard to 33% loss of time and increase of labor in using the metric system on railway location and construction is not borne out by the facts. Granted a third more stakes have to be lined in and driven, that is only a small part of the work of railway location, and that is the only extra work involved. This is offset many times by the labor saved in calculating the cross-sections.

As a matter of fact there is very little country where cross-sections do not have to be taken oftener than once every 100 ft., so that the extra labor in setting stakes every 20 m. (66 ft.) is more apparent than real.

It is to be deplored that these extravagant statements should be made on either side. There are of course many weighty and valid arguments against the general adoption of the metric system, but I think you will find very few engineers who have used the metric system on railway location and construction who are not ardent advocates of it, on that work, at least.

Yours truly, F. Lavis,

Assoc. M. Am. Soc. C. E.

Albany, N. Y., Feb. 23, 1903.

The Metric System in Railway Construction.

Sir: In my letter, published in your issue of Feb. 19, I want to make a correction. In the sixth paragraph the abbreviation "ft." after the quantity 20 should have been omitted, making the paragraph read:

This feature of simplicity in the calculation of quantities with a length of 20 is not peculiar to the metric system, but is due to the coincidence of the length of the station finally adopted.

In this connection I want to say in answer to Mr. Haines (Eng. News Feb. 19) that the 25-m. chain has not before been mentioned in this discussion. Further, in my letter (Eng. News Jan. 15) my statement is that the 20-m. station is used. When it is used, "1% of 10 stations is not 1 meter but 2 meters" is correct, and his remark, "I cannot imagine how he got such an idea" is entirely uncalled for in every sense. The first requisite of a discussion is to read correctly and understandingly.

Any engineer who has not had experience with the workings of the metric system as applied to the making and use of a profile can, if he will, demonstrate to his own satisfaction the comparative merits of the two systems. Let him plat 10 stations or more on "Plate A" profile paper, which is used in Mexico. Let the division representing 5 ft. vertically equal 1 m. The stations will be 20 m. (or 66 ft.). Now plat any ground line. It will be seen by inspection that it requires 50% more paper, labor and time, which is occasioned by the shorter station. Now plat a 1% grade line, remembering that the station is 20 m. (not 10 m.) and the rise (or fall) will be 2 m. for 10 stations.

Suppose now we try the system suggested by "C. S." (Eng. News, Dec. 25) of marking the stakes with even numbers and assuming the imaginary station to be 10 m. Platting a profile on this basis would require twice as much paper as the 20-m. station, besides, in order to do this platting, the rod readings would have to be taken at each 10 m., thereby doubling the work in the field and office over the 20-m. station. And yet we find that the 20-m. station already makes 50% more work over the American system on the level notes and profile, correspondingly increases the liability to error, introduces still another liability to error in figuring grades, and presents no improvement over the American system.

On construction with 10-m. stations the cross-section would then have to be taken at every 10 m. and lose the benefit of the factor 20 in the calculation of earthwork, or at the 20-m. station, thereby acknowledging the metric to be "a makeshift of a decimal system." The latter is the case.

In running curves by deflection angles, fractional stations fall more frequently on even feet than on even meters, and therefore the engineer has more "trouble with those annoying and distracting decimals of a degree" in the metric than in the foot system. Moreover, it does not sound well for an advocate of a decimal system, whose only recommendation is that it *is* a decimal system, to find fault with another system because of its "annoying and distracting decimals."

Yours respectfully, A. S. Robinson.

St. Ignace, Mich., Feb. 26, 1903.

How to Make a Quick Change to the Metric System.

Sir: The letter in your issue of Feb. 19 entitled "A Big Job for a Literary Engineer" is about the best considered article that has appeared opposing the change to the metric system. I do not think M. Am. Soc. M. E. has at all exaggerated the immense amount of rewriting and duplication that would be caused by a *gradual* change. If American and British engineering practice can be successfully carried on independent of the rest of the world, the change is perhaps prohibited by the expense; but any progressive engineer must make use of all the information available, and much of the best of it is written in French and German expressed in the metric system. If he is to work for parties outside of English-speaking countries, he must use the metric system. For comparison and conversion of data he now has to be his own "literary engineer" and reduce data to one or the other system. He is now, whether he wills or not, in the midst of that voluminous "transition period" so appallingly dilated upon by M. Am. Soc. M. E., and the burden comes heavy upon him.

Fortunately, but unintentionally, "M. Am. Soc. M. E." has suggested the way in which the change can be made quickly:

In Russia or Turkey it might be decreed by the Czar or the Sultan that from and after a certain future date no book, newspaper or other publication should make any measurement that was not a metric one under penalty of imprisonment or the bowstring. . . . . But such a decree could not be made in any Anglo-Saxon country.

Why not? If Congress should prohibit from transmission through the mails any printed matter in which all measurements were not given, either originally or in parentheses, in the metric system, the change would be made quick enough by the papers and periodicals. If people see all their printed measurements in the metric system they will soon use it.

Congress can do more than this; it can compel the use of the metric system in interstate commerce, in all government work, customs and land survey business included.

It may be expensive in the latter instance, but the American people will stand the expense patiently enough. The system must be made compulsory just as far as it is possible to do so. The change must be quick and thorough. Half-way measures will not do.

Yours truly, Harrison Everett Ashley,
Chemical Engineer.

Leetonia, O., Feb. 25, 1903.

(Let our correspondent (if he can) imagine himself a member of Congress called to vote on such a bill as he proposes. What would his farmer constituents say to a law which gave them their market quotations for produce in cents per kilogram? What a fine opportunity any such compulsory legislation would give to the party in opposition. The political managers may be careless in some respects, regarding public opinion on legislative matters; but when it comes to legislation uprooting established customs, they are exceedingly careful what laws they enact. Imagine the popular outburst if the editor of an influential political journal which chose to oppose and defy the law were carted off to prison. If must be evident that such a law or any law making compulsory the use of the metric system would either be a dead letter or attempts at its enforcement would lead to a popular opposition which would result in its immediate repeal.—Ed.)

Metric Exaggerations.

Sir: One of your correspondents in Engineering News of Feb. 19 intimated that in the event of the adoption of the metric system in the United States, a large body of metric literature was likely to be created. A good beginning has already been made, as your columns can testify. May I venture to swell the mass, by the mention of a few points which it appears to me should not be lost sight of in the discussion?

Let me premise by saying that I belong to the class which perhaps has the best right to form and express an opinion on the subject, having used both the English and metric systems in a somewhat extended engineering practice at home and abroad, beginning with my education in a French engineering school.

In the first place, I think there is exaggeration on both sides, as to the respective merits and demerits of the two systems. Every art and science employing weights and measures can be carried on with perfect success by either. There exists no long-felt want for a better system of weights and measures either in America, England or the metric countries; neither does any one experience any serious difficulty in passing from one system to the other after the small degree of practice which the use of any new instrument demands. At least, we have no difficulty and not much trouble in passing from our system to the metric, the moment we accept it on its merits, and cease to translate it back into English. Mr. Haines has already called attention to this point. If we were to adopt the metric system, even admitting for the argument that it is better than ours, we would not find our work of measuring, recording and calculating materially lessened. Long calculations would be as troublesome and as liable to error as ever, and probably the majority of people, not specialists in any particular art, would be unable to say which they preferred, after a fair trial. The civil engineer would be especially at a loss to decide, because he uses the decimal system already. The railroad engineer would probably find that 20-meter stations were inconveniently short on tangents, but were not bad on curves, and either way would be thinking too much of his location and other important matters, to care greatly which he was using. I believe the same would be true in the case of the metrical railroad man; he would use feet and hundredths just as readily as meters and hundredths. It is not worth talking about, either way, only neither would be in the least benefited by the change from his former practice, as soon as the necessary field books were prepared.

I believe the radical defect of the metric system, pure and simple, is that it proceeds on the assumption that it is possible to have one unvarying standard of weighing and measuring for all uses, small and great. You might as well, hyperbolically speaking, ask the blacksmith to use the same tools as the carpenter, and a single tool at that. I grant that if we must have the same yard stick to measure the interstellar spaces and the eye of a needle, the metric system is as good as any I happen to know of, but why should we so limit ourselves? I think it is characteristic of the grand industrial race that uses English measures, that each trade uses the unit and subdivision best suited to its purpose, with perfect indifference as to whether or no any one else likes it. The reproach made against our system on the grounds of its complexity seems to me to be its greatest merit from the practical point of view.

Another point: The majority of the arguments in favor of the metric system seems to be based upon the alleged greater facility in calculation. I believe this to be the least important of the requirements of a system of weights and measures. The first essential is the ease and accuracy with which we can perform the act of weighing and measuring material objects, and with which the artisan can work to measurement. The measurer and handicraftsman are the ones to be favored, not the computer. If the skilled workman in the machine shop can work to best advantage to inches divided by successive bisections, that is the best unit for machinery, even if the office work becomes considerably more intricate.

A uniform system, the world over, would be a great convenience. A uniform currency would be a still greater. Perhaps some day we may come to both. But for the nonce, I expect to continue using my footrule in the United States, and my "double decimeter" in metric countries with perfect ease and content, as long as I am fortunate enough to have engineering to do in either.

A practical suggestion: Let anyone interested in the matter procure a pocket rule divided to inches on one side and centimeters on the other, and use it constantly in measuring things. Then he can draw his own conclusions.

E. Sherman Gould.

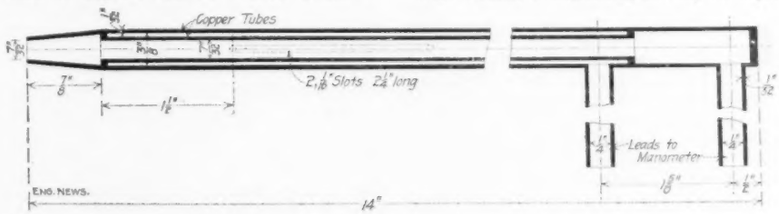
Yonkers, N. Y., Feb. 23, 1903.

A Form of Pitot Tube for Measuring Air Velocities.

Sir: Having read with much interest the article on the "Cole Flad Photo-Pitometer" in your issue of Feb. 5, 1903, I venture to call your attention to a form of Pitot tube which has been developed here under my direction for the purpose of determining the velocity of air. The practical difficulty with the Pitot tube is in obtaining an accurate indication of the static pressure. As regards water it has been fully demonstrated by experiment that the pressure obtained from the impact end of the Pitot tube agrees with the theoretical formula:

$$V^2 = 2\,GH.$$

When it comes to determining not only the impact pressure, but the static pressure of the water or other fluid in a pipe and in motion, there are practical difficulties in the way.



A PITOT TUBE FOR DETERMINING AIR VELOCITIES.

The accompanying plans show the tube which I used for the experiments with air. It consists essentially of two concentric tubes, each with a separate lead to a manometer. The inner tube, or the impact tube, records the total head and the other tube the static pressure in the moving air. The axis of the tube is, of course, placed parallel to the axis of the pipe. It is seen that it has two slots, opposite one another.

In order that the pressure in the moving mass of air may be communicated to the manometer it must be transmitted across a varying surface of discontinuity which separates the moving air from the still air in the tube. The accurate transmission of this pressure is evidently facilitated if the surface is comparatively long in the direction of motion of the air and so provided for that it changes position as little as possible. Theoretically through the insertion of a tube into a stream of air the velocity of the air along the outside of the tube is slightly increased above the normal velocity of the stream and the corresponding pressure diminished, but with the comparatively small size of the tube this effect is infinitesimal.

The results obtained with this form of tube have been very satisfactory. When one of these tubes is placed in a free jet of air issuing from an open pipe and gradually removed from the mouth it is found that the static pressure recorded through the slots, while appreciable close to the pipe, falls off steadily as the tube is removed until at a distance of 7 or 8 ft. from the mouth of a 12-in. pipe the static pressure becomes almost too small to measure, even in a very strong current of air. Of course, at such a distance from the pipe, the pressure in the jet of air could be but a very little above that of the atmosphere, and this rough test indicates that using this type of tube and the theoretical formula the resulting velocity will not be greater than the truth.

I might add that my friend Professor Zahm, of the Catholic University here, has quite recently made experiments with similar slotted Pitot tubes in currents of air whose velocities were accurately measured by other means, and has found that the velocity obtained by the theoretical formula from the Pitot tube agrees with the actual velocity measured by other means within the small experimental limits of error.

The form of Pitot tube described above would seem to have such obvious advantages that it has probably been used before, but in such literature as I have been able to see on the subject I have not found it described.

Very respectfully, D. W. Taylor,
Naval Constructor, U. S. N.

Navy Yard, Washington, D. C., Feb. 17, 1903.

A Method of Calculating Longitudinal Shear in Concrete-Steel Beams.

Sir: I have read with interest the article on concrete-steel beams, which appeared in Engineering News of Feb. 12, 1903. Ever since I have been with the Concrete-Steel Construction Co., it has been our practice to compute carefully the number of U-bars which were necessary to take up the longitudinal shear. Our method of computation of this stress is here given, with the belief that it may prove of some interest to readers engaged in the design of concrete-steel construction.

S = intensity of longitudinal shear;
V = vertical shear at section under consideration;
h = effective depth of beam;
b = width of beam;
x = distance between extreme compression fiber and the neutral axis,

$$b\,S = \frac{V}{h - \frac{x}{3}}.$$

This equation can be very readily established.

It is seen that the intensity of shear varies linearly with the vertical shear and that both reach their maximum at the same section, at the supports. The intensity of shear given by the above equation is the same for all points of a section on the tension side of the neutral axis.

In practice it will be usually found necessary to compute the total longitudinal shear for about the one-fifth span adjacent to the supports of the beam. The summation involved in obtaining the total longitudinal shear can be done analytically or graphically.

For a simple and non-continuous beam acted upon by a uniform load p per unit length, b S may be obtained for the section at the point of support, and any other section from the point of support at a distance y. The total longitudinal shear between the two sections will be,

$$\frac{y}{2}\,[(b\,S)_0 + (b\,S)_y] = \frac{p\,y}{2} \cdot \frac{l - y}{h - \frac{x}{3}};$$

l being the span of beam.

Yours truly, S. D. Bleich.

Mitchell Building, Cincinnati, O., Feb. 15, 1903.

THE IMPROVEMENT OF THE ENTRANCE TO CUMBERLAND SOUND, GEORGIA AND FLORIDA.

By James H. Bacon,* M. Am. Soc. C. E.

GENERAL CHARACTERISTICS OF ENTRANCE.

Previous to beginning the work of improvement, the characteristics of this entrance were those common to most harbor entrances on the South Atlantic coast.

A deep gorge, known as Amelia Basin, extended from the inner sound out between Cumberland and Amelia Islands, for a distance of about one-half mile from the latter, and has continued essentially unchanged for many years. At its seaward end occurred the shifting of the channel so common on this coast. The direct course to the northeast across the bar was, at irregular intervals, slowly deflected southward by the encroachment of the sand coming from the north, until its increasing length became too great for maintenance when (usually in some storm) the outflowing tide again forced a new channel straight across the bar and the same cycle of changes was again resumed.†

The work of improvement in the early years was described as follows in the annual report of the Chief of Engineers in 1898:

The available depth of the entrance in its unimproved condition varied from 11 to 12.5 ft., at mean low water. The mean rise and fall of tide is 5.9 ft. The original plan of improving the entrance was submitted in 1879, and is given in the annual report of the Chief of Engineers for that year. A revised plan was submitted in 1891. A

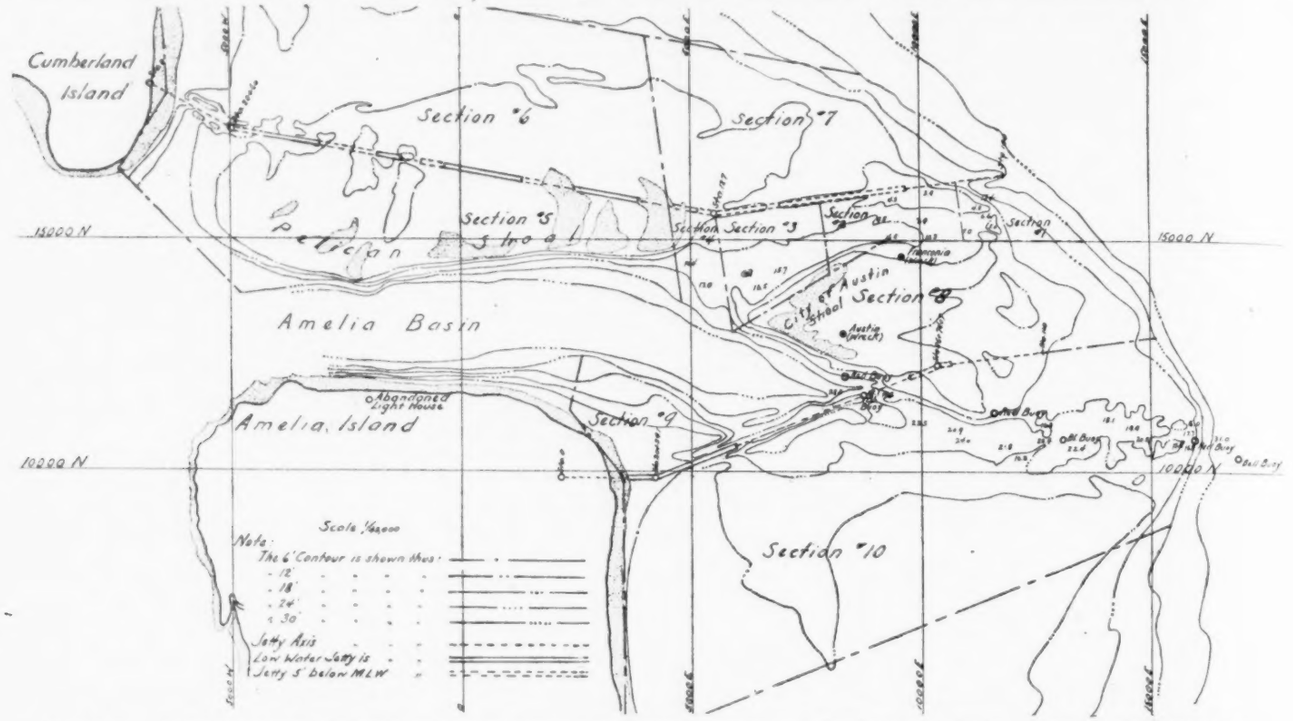
*U. S. Assistant Engineer, U. S. Engineer's Office, Fernandina, Fla.

†See Report of Board of Engineers in annual report of Chief of Engineers, for 1891, p. 1598.

second revision of the plan of improvement was submitted in 1895, and is printed in annual report of the Chief of Engineers for 1896, p. 1289 et seq. It contemplated the construction of two jetties, composed of riprap stone, with a hearting of small stone, resting upon a foundation mattress of brush, starting, respectively, from the shores on opposite sides of the entrance and extending seaward across the bar. These jetties are intended to establish a mean low water channel across the bar of 19 ft. in depth.*

consisted of two courses of these multiple mattresses. The amount of stone placed on these mattresses was inconsiderable, but was sufficient to reduce the height of the mattress by 50 or 60%. The jetty extended about 19,400 ft. from the shore. The first 17,000 ft. of this was placed in comparatively shoal water so that the crest of this portion, except for a few gaps, was at about

nothing was done on the jetties until Nov. 23, 1900, when work was resumed under a contract with Messrs. Christie, Lowe and Heyworth. At this time the jetties were in about the same condition as in 1897, except that that part formed by the multiple mattresses had practically disappeared. This condition, as well as the adjacent hydrography, is shown on Map No. 1.



MAP NO. 1. ENTRANCE TO CUMBERLAND SOUND BEFORE BEGINNING WORK ON PRESENT CONTRACT. FROM SURVEY MADE IN JUNE, 1900.

This project was authorized by the river and harbor act of June 3, 1896. The cost of the improvement was originally estimated at $2,071,023, as revised in 1891 at $2,079,500, and as revised in 1895 at $2,350,000, for completion. Revision of the estimates was rendered necessary from the fact that funds had been supplied irregularly and in entirely inadequate amounts for the proper prosecution of the work.

Previous to the adoption of the project of 1895 the sum of $932,500 had been expended on the improvement, resulting in carrying the foundation of the north jetty 18,308.8 ft. and of the south jetty 10,062.48 ft. seaward. There had been used in this work 574,276 sq. yds. of mattresses, 133,836.74 cu. yds. of riprap stone, and 2,071.8 cu. yds. of oyster shells.

Under the provisions of the river and harbor act of June 3, 1896, a contract was entered into Oct. 8, 1896, for all jetty work required for completion of the improvement. Work was commenced on Dec. 7, 1896, and continued to Oct. 9, 1897, on which date the contractor suspended operations.

This suspension of work was brought about by the charges of fraud, which have resulted in the conviction of Capt. O. M. Carter, the officer in charge of the work, and in the flight from the United States of J. F. Gaynor and B. D. Greene, the principal members of the Atlantic Contracting Co., to whom the contract had been let.

At the time of this suspension the jetties were, substantially, in the condition described below:

NORTH JETTY.—This consisted of a layer of log and brush mattresses covered with a thin layer of light Florida stone from the shore for a distance of about 14,500 ft. (Sta. 15,000). From that point to the end of the jetty, a distance of 5,400 ft. (Sta. 20,400) it consisted of the multiple mattress placed by the Atlantic Contracting Co., covered with a small quantity of Florida stone. The multiple mattresses consisted of layers of 4, 6 or 8 loosely-built single brush mattresses built on a barge designed for the purpose and bound together with rope or wire. The resultant height of these layers was from 8 to 12 or 14 ft. A portion of the outer end of the North Jetty

*See p. 1289, Ch. of Eng. Rep., 1896, Rep. of Bd.

low water. The crest of the remainder sloped from low water to about 25 ft. below.

SOUTH JETTY.—This was a layer of log mattresses which were covered with Florida stone for a distance of about 8,800 ft. from the shore (Sta. 10,060), and from there to the end, a distance of about 3,800 ft. (Sta. 13,855) it consisted of one course of multiple mattresses covered with a thin layer of Florida stone. The crest of this jetty was at about low water for a distance of about 2,600 ft. from the shore. From there to the outer end it varied from 6 ft. to 12 ft. below low water. A portion of this jetty had been removed to form a sailing gap for vessels, the channel having shifted so far to the south as to cross this jetty about midway between its extremities.*

From the suspension of work in November, 1897,

*See p. 1656, Rep. Ch. of Engrs., 1901.

Table I. shows the amount of material that had been placed previous to the end of each fiscal year and the cost thereof.

At present it is planned to build the north jetty to high water throughout, from the shore to Sta. 19,500. The outer 6,800 ft. of this is to have a superstructure of heavy granite blocks, 15 ft. wide on top, 13 ft. high, and 44 ft. wide at the bottom, resting on a substructure of granite riprap 54 ft. wide on top, with side slopes of 1 vertical to 2 horizontal. The substructure begins at 5 ft. below m. l. w. The remainder of the north jetty has a cross-section of similar shape, with the top width 8 ft. instead of 15.

The south jetty is to be built to high water from the shore to Sta. 11,000, unless it develops that a shorter high water jetty will do the required work. In this case the substructure will be carried to Sta. 11,000 and the superstructure stopped

TABLE I.—Official Record of Contract Work at Cumberland Sound; 1880 to 1902.

Contracts. No.	Begun.	Ended.	Contract prices. Mattress sq.yd.	Stone 1st & 2d class, ton.†	Stone 3d & 4th class, cu.yd.*	Shell, cu. yd.	Fiscal year ending.	Total cost at end of fiscal year.	Total amounts in place at end of fiscal year. Mattress, sq.yds.	Stone, cu.yds.	Shell cu. yds.
1.	June, 1881	Nov., 1881	.....	....	.....	....	.....				
2.	Dec., 1881	Sept., 1882	$0.97	....	$3.85	....	June 30, 1881				
3.	Oct., 1882	Mar., 1883	.85	....	3.70	....	June 30, 1882				
4.	Dec., 1884	June, 1885	.59	....	3.09	....	June 30, 1883	$306,783	153,953	49,228	.....
5.	Jan., 1887	Nov., 1887	.47	....	2.89	....	June 30, 1884				
...	.....	.....	....	....	....	....	June 30, 1885				
...	.....	.....	....	....	....	....	June 30, 1886				
...	.....	.....	....	....	....	....	June 30, 1887				
...	.....	.....	....	....	....	....	June 30, 1888..	358,676	191,678	61,049	.....
6.	Mar., 1889.	Nov., 1889	...	....	3.27	$1.27	June 30, 1889..	394,519	191,678	71,562	1,154
...	.....	.....	....	....	.....	....	June 30, 1890..	454,616	191,678	89,623	818
7.	June, 1891	Nov., 1891	.97	....	3.49	....	June 30, 1891..	458,636	194,448	90,005	.....
...	.....	.....	....	....	.....	....	June 30, 1892..	555,514	253,207	101,435	.....
8.	Oct., 1892	May, 1893	1.05	....	3.59	....	June 30, 1893..	717,760	360,942	115,119	.....
9.	Nov., 1894	June, 1895	.57	....	2.00	....	June 30, 1895..	876,857	574,276	133,867	.....
10.	Dec., 1896	Oct., 1897	1.10	$5.25	3.90 and 3.50	....	June 30, 1897..	1,325,596	920,564	152,166	.....
...	.....	.....	....	....	....	....	June 30, 1898..	1,481,542	1,032,432	161,521	.....
					Present Contract.						
11.	Nov., 1900	Still in force..	....	2.15	1.90	....	June 30, 1901..	258,202	None.		98,200 or 122,793 tons
	Totals under present contracts.....					....	June 30, 1902..	812,502	None.		308,300 or 385,387 tons.

*For foundation mattress covered with 1 ft. of stone if constructed: 1st design, $12.34 per lin. ft. of width of 54 ft.; 2d design, $12.49 per ft., same width; 3d design, $11.59, same width. Additional stone, $3.34 per cu. yd.
†Ton of 2,000 lbs.

at a suitable point. The cross-section of this jetty is the same as the inner end of the north jetty.

A reference to Table I. shows that at the beginning of work under the present contract there were 161,520 cu. yds. of stone in place in both jetties. It can be assumed that the mattress work added practically no bulk to the work. When the jetties are completed the total volume will be 857,800 cu. yds. Hence, the work done previous to the present contract is about 19% of the whole. As a considerable portion of this previous work is outside the lines required by the present scheme, this percentage can be reduced to 15% at most. In consideration of this fact and that the previous work had had no effect whatever in improving the entrance, it may be said that the actual work of improvement began with the present contract.

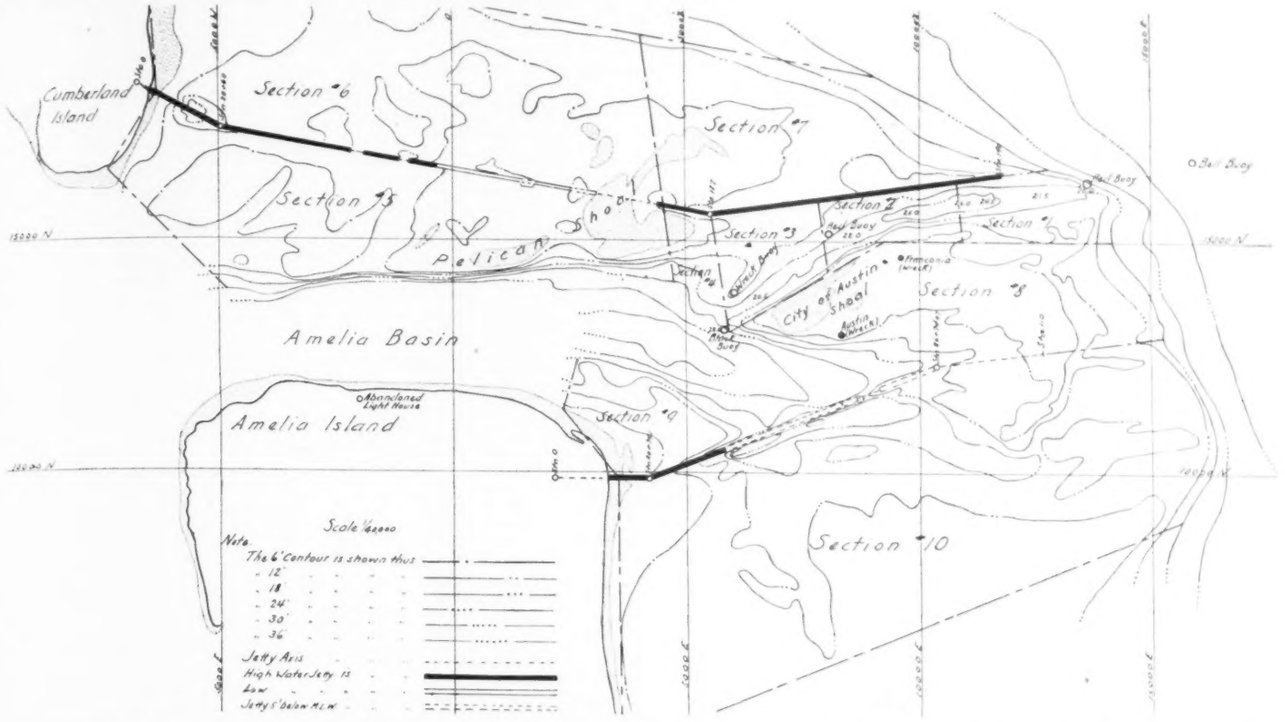
Work under this contract is still under way, and while great changes for the better have resulted, it is safe to predict that the improvement shown at present will be only a small proportion of that which will result from the completed jetties. It is expected that they will be completed by May, 1903. Map No. 2 shows the condition of the jetties and adjacent hydrography in June, 1902. The changes shown have been brought about by the work done on the jetties under the present contract, assisted by a small amount of dredging.

This work has been so directed as to bring about the desired results in the shortest possible time, but much credit must be given the contractors for a vigorous prosecution of the work.

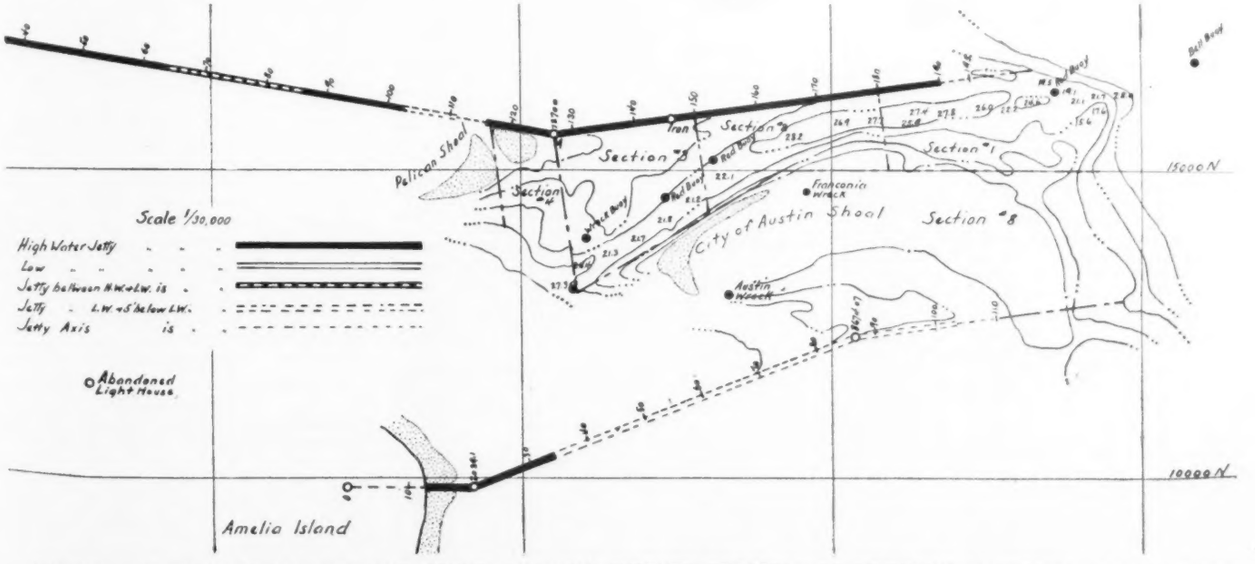
When the work began it was foreseen that the natural location for the channel, at that time, was under the lee of the north jetty, that the "City of Austin Bank," to the south of this location, would act, temporarily, as a south jetty, and thus render immediate work on the south jetty unnecessary, and that building up the north jetty to high water would keep out of the channel the sand drifting down the coast from the north.

The result has been that a channel has been formed as expected, in which the available m. l. w. depth has been increased from 6½ ft. to 20 ft. A portion of this increased depth is due to dredging, the necessity of which is explained later.

The first work done was to raise the outer end of the north jetty to mid-tide, and subsequently to high water; then a short section next to the shore was built to high water, closing a subsidiary channel; then the work of closing the gap between the two ends was begun and is still going on. Meanwhile stone has been placed on the south jetty whenever it has been practicable to do so with-



MAP NO. 2. ENTRANCE TO CUMBERLAND SOUND, SHOWING CHANNEL DEEPENED TO 20 FT. FROM SURVEYS MADE JUNE 10-23, 1902.

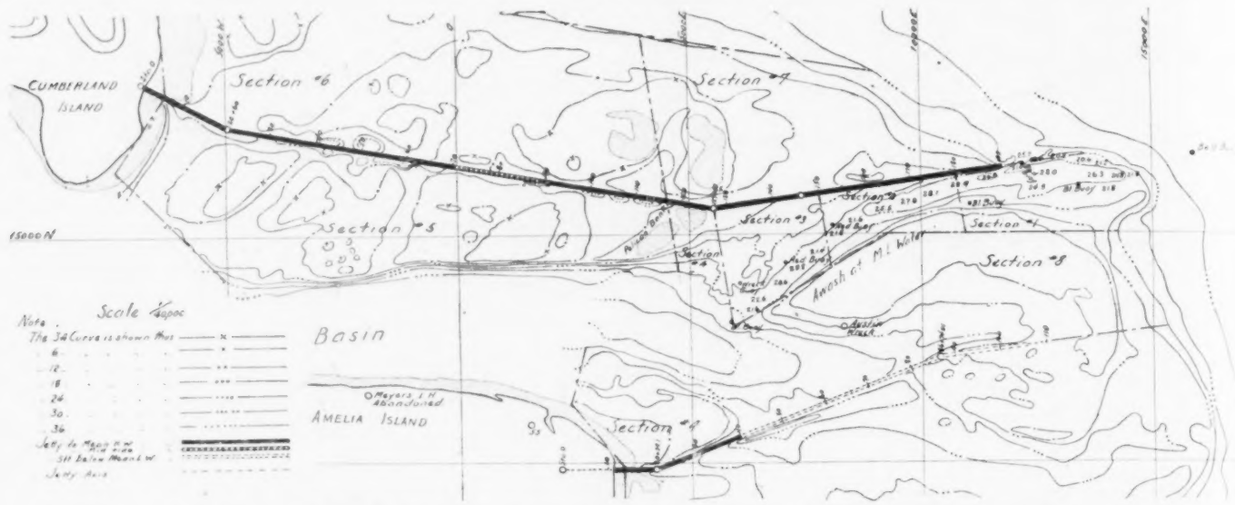


MAP NO. 3. ENTRANCE TO CUMBERLAND SOUND, SHOWING FURTHER PROGRESS OF DEEPENING BY JETTIES. FROM SURVEYS MADE OCT. 8-13, 1902.

out neglecting the north jetty. No mattresses have been laid under the present contract and none are contemplated. It has been proved, to the satisfaction of the writer, that mattresses of any kind are a useless expense in connection with jetties or similar structures, which are to be placed on a hard sand bottom. Log mattresses accelerate scour and settlement, and brush mattresses form no part of the bulk of a jetty after the superstructure is in place. Some of the outer end of the north jetty, and 2,500 ft. of the south jetty, has been placed on sand with no appreciable settlement nor scour around the end. The foundation course was in each case from 70 ft. to 130 ft. wide, and of granite riprap.

Early in the spring of 1902 the exigencies of the work required that the sailing gap in the south jetty should be closed, and dredging was resorted to in order to accelerate the deepening of the north jetty channel. At that time the available depth in this channel was about 14 ft. at low water. Dredging ceased in August, 1902, when an available depth of 20 ft. at low water had been secured after the removal of 194,652 cu. yds. This depth has been increased without dredging to 21 ft. at the present date.

Table II. shows the resultant movement of sand in each of the sections shown on the maps at various intervals between June, 1900, and June, 1902.



MAP NO. 4. ENTRANCE TO CUMBERLAND SOUND, FROM SURVEYS MADE IN DECEMBER, 1902.

TABLE II.—SAND MOVEMENT AT CUMBERLAND SOUND, AS DETERMINED FROM SURVEYS.

No. of survey	Date.	Intervals in days. Bet. surveys	Intervals in days. From 1st survey	Areas of sections at m. l. w. depth of 24 ft., sq. yds.	No. of section.	Volume of sand above m. l. w. depth of 24 ft., cu. yds.	Total sand movement during intervals between surveys. Fill, cu. yds.	Scour, cu. yds.	Scour, per day, yds.	Totals in sections 1, 2, 3 & 4 (area of new channel), cu. yds.	1, 2, 3, 4, 5, 8 and 9 (area bet. jetties), cu. yds.	6, 7 and 10 (area outside of jetties), cu. yds.
1	June 5, 1900	...	...	281,000	1.	1,049,000	.....	.....	.....	.....	.....	.....
				449,000	2.	2,482,000	.....	.....	.....	.....	.....	.....
				549,000	3.	2,223,000	.....	.....	.....	.....	.....	.....
				223,000	4.	857,000	.....	.....	.....	.....	.....	.....
2	Feb. 1, 1901	240	...	309,000	1.	1,073,000	24,000	.....	100	.....	.....	.....
				449,000	2.	2,173,000	.....	309,000	1,287	.....	.....	.....
				549,000	3.	2,188,000	.....	35,000	145	.....	.....	.....
				240,000	4.	775,000	.....	82,000	342	— 402,000	.....	.....
3	May 2, 1901	90	330	317,000	1.	1,232,000	159,000	.....	1,767	.....	.....	.....
				449,000	2.	1,885,000	.....	288,000	3,200	.....	.....	.....
				549,000	3.	2,178,000	.....	10,000	110	.....	.....	.....
				233,000	4.	836,000	61,000	.....	678	— 78,000	.....	.....
				332,000	1.	1,247,000	15,000	.....	250	.....	.....	.....
		60	390	449,000	2.	1,741,000	.....	144,000	2,400	.....	.....	.....
				549,000	3.	2,217,000	39,000	.....	650	.....	.....	.....
				234,000	4.	877,000	41,000	.....	683	— 49,000	.....	.....
4	July 1, 1901	...	...	3,143,000	5.	19,694,000	.....	.....	.....	.....	.....	.....
				4,200,000	6.	24,274,000	.....	.....	.....	.....	.....	.....
				2,120,000	7.	11,024,000	.....	.....	.....	.....	.....	.....
				2,128,000	8.	11,299,000	.....	.....	.....	.....	.....	.....
				701,000	9.	3,470,000	.....	.....	.....	.....	.....	.....
				6,897,000	10.	27,663,000	.....	.....	.....	.....	.....	.....
5	Aug. 20, 1901	50	440	345,000	1.	1,327,000	80,000	.....	1,600	.....	.....	.....
				449,000	2.	1,673,000	.....	68,000	1,360	.....	.....	.....
				549,000	3.	2,152,000	.....	65,000	1,300	.....	.....	.....
				230,000	4.	834,000	.....	43,000	860	— 96,000	.....	.....
6	Oct. 26, 1901	67	507	370,000	1.	1,411,000	84,000	.....	1,254	.....	.....	.....
				449,000	2.	1,548,000	.....	125,000	1,866	.....	.....	.....
				549,000	3.	2,144,000	.....	8,000	119	.....	.....	.....
				229,000	4.	791,000	.....	43,000	43	— 92,000	.....	.....
				388,000	1.	1,473,000	62,000	.....	939	.....	.....	.....
		66	573	449,000	2.	1,364,000	.....	184,000	2,788	.....	.....	.....
				549,000	3.	2,188,000	44,000	.....	651	.....	.....	.....
				240,000	4.	798,000	7,000	.....	106	— 71,000	.....	.....
7	Dec. 30, 1901	...	...	3,186,000	5.	19,829,000	135,000	.....	737	.....	.....	.....
				4,201,000	6.	24,708,000	434,000	.....	2,371	.....	.....	.....
				2,131,000	7.	10,793,000	.....	231,000	1,262	.....	— 514,000	.....
		183	183	2,123,000	8.	11,510,000	211,000	.....	1,153	.....	.....	.....
				760,000	9.	3,398,000	.....	72,000	393	.....	.....	.....
				6,900,000	10.	27,033,000	.....	60,000	328	.....	.....	+ 143,000
8	Mar. 20, 1902	80	653	452,000	1.	1,506,000	33,000	.....	425	.....	.....	.....
				449,000	2.	1,329,000	.....	35,000	437	.....	.....	.....
				549,000	3.	2,231,000	43,000	.....	537	.....	.....	.....
				242,000	4.	888,000	90,000	.....	1,125	+ 131,000	.....	.....
9	May 1, 1902	*42	695	470,000	1.	1,295,000	.....	211,000	5,024	.....	.....	.....
				449,000	2.	1,227,000	.....	102,000	2,429	.....	.....	.....
				549,000	3.	2,090,000	.....	141,000	3,357	.....	.....	.....
				229,000	4.	839,000	.....	49,000	1,167	— 503,000	.....	.....
				493,000	1.	1,363,000	68,000	.....	1,417	.....	.....	.....
		†48	743	449,000	2.	1,238,000	11,000	.....	229	.....	.....	.....
				549,000	3.	2,075,000	.....	15,000	312	.....	.....	.....
				241,000	4.	879,000	40,000	.....	833	+ 104,000	.....	.....
10	June 18, 1902	...	...	3,181,000	5.	18,885,000	.....	944,000	5,553	.....	.....	.....
				4,185,000	6.	24,957,000	249,000	.....	1,405	.....	.....	.....
				2,160,000	7.	11,164,000	371,000	.....	2,182	.....	— 1,681,000	.....
		170	353	2,111,000	8.	11,085,000	.....	425,000	2,500	.....	.....	.....
				772,000	9.	3,354,000	.....	44,000	259	.....	.....	.....
				6,928,000	10.	28,539,000	936,000	.....	5,506	.....	.....	+ 1,556,000

*18,000 cu. yds. were dredged during this interval from Sections 1, 2, 3 and 4.
†54,000 cu. yds. were dredged during this interval from Sections 1, 2, 3 and 4.
On March 31, 1902, dredging was begun in the channel through Sections 1, 2, 3 and 4; ceased on Aug. 20th, 1902.
In the total columns + = fill; — = scour.

An inspection of this table shows that between June, 1900, and June, 1902, 1,056,000 cu. yds. of sand were moved from the sections 1, 2, 3 and 4, through which the new channel passed. Of this 102,000 cu. yds. were removed by dredging, leaving a balance of 954,000 cu. yds. that were moved by the scouring action, due mostly to the north jetty.

During the period from July, 1901, to June, 1902, a fill of 823,000 cu. yds. took place in the sections north of the north jetty, a fill of 876,000 cu. yds in the section south of the south jetty, a scour of 809,000 cu. yds. from the Pelican Bank shoal, and a scour of 214,000 cu. yds. from the City of Austin Shoal. Hence, a desired fill of 1,699,000 cu. yds., and a desired scour of 1,977,000 cu. yds. has been caused inside of two years by the construction of the jetties under the present contract.

All of the stone placed on the jetties previous to the present contract was Florida limestone weighing about 125 lbs. per cu. ft. The individual stones averaged about 20 lbs. in weight, and the heaviest did not exceed 150 lbs.

Under the present contract practically all stone placed has been granite, which weighs 160 lbs. per cu. ft. In the superstructure there has been placed 192,431 tons of first-class stone, consisting of heavy granite blocks, each weighing from ½-ton to 15 tons. One-half or more of this tonnage consists of blocks weighing 5 tons or more.

In the substructure (below 5 ft. below low water) 192,956 tons of second and third-class stone has been placed, consisting of granite riprap. The individual stones weigh from 10 lbs. to 1,000 lbs., and average 50 lbs.

ADDENDUM.

The above article was written in October, 1902. Since then two surveys have been made and the results of the latest survey are shown on Map No. 4. The available depth across the outer bar has been increased to 25 ft. at low water, while that on the inner bar remains about the same. No dredging has been done. The north jetty will probably not be extended beyond its present end (Sta. 19,000).

Calculations from Map No. 4 show that from July, 1901, to January, 1903, the following movement of sand has occurred:

1,318,000 cu. yds. fill in the sections north of north jetty.
644,000 " " fill in the sections south of south jetty.
834,000 " " scour from the channel sections.
1,011,000 " " scour from Pelican Bank Shoal.
1,442,000 " " scour from City of Austin Shoal.
Total fill, 1,962,000 cu. yds.
Total scour, 3,287,000 cu. yds.

James H. Bacon.

Fernandina, Fla. Jan. 24, 1903.

A WIRE-TESTING MACHINE for giving a bending test to wire under tension is described by Mr. Arthur Falkenau in a paper read before the Engineers' Club of Philadelphia on Nov. 1, 1902, and printed in the club's "Proceedings" for January, 1903. Starting with the assumptions that the most serious wear on wire ropes is due to the constant bending when under strain over sheave wheels or drums and that this deterioration increases proportionately with greater speed, the author of the paper argues, that to make a quality of rope that will handle the greatest possible tonnage wire must be selected that will stand the highest number of bends of not less than 90° under a load uniformly proportionate to its ultimate strength. In place, therefore, of the usual torsion and elongation tests Mr. Falkenau proposes the following: Each end of a coil of wire should first be tested to ascertain the ultimate strength. If this result is in accordance with the requirements, the next operation is the bending test. This is accomplished by clamping the test piece between jaws and bending the wire through an arc of 180°, using jaws with a radius corresponding to the diameter of the wire in each case. If the number of bends which the wire withstands falls below that which is called for by a table of past records, then the coil is rejected. The machine described in the paper is a simple device for making the bending test while the wire is under tension.

A PROTECTED THIRD-RAIL is used on a new electric interurban line in Pennsylvania, the Wilkesbarre & Hazleton R. R., just completed. A pine plank, 2 × 6 ins., serves as a roof to protect the third rail from snow and sleet and accidental contact of persons. Short oak posts, 8 ft. c. to c., serve to support this protecting plank. The details of the arangement are illustrated and described in the "Street Railway Journal" of March 7.

A BLAST FURNACE TO UTILIZE FLUE DUST.

A small blast furnace built especially to work up flue dust, was recently erected by the Northside Iron Co. at Shapsville, Pa., where thousands of tons of flue dust are to be had for the cost of removal. In all respects the design of the larger stacks of to-day has been closely followed, but with greatly reduced dimensions.

The stack is only 35 ft. high, and has a 7½ ft. bosh. One iron stove with 18 pipes is sufficient to heat the blast.

Last summer the first experiments were made with flue dust. The stack then had an 11-ft. extension above the stock line for the purpose of preventing too great a quantity of flue dust from blowing out of the top of the stack; but the operation in this way did not prove successful, for it was found impossible to keep the charging doors cool, located as they were just above the stock line; furthermore, imperfect fitting of these doors made charging decidedly hazardous. To still further retain the charge of flue dust, the downcomer was placed 1½ ft. from the top or 9½ ft. above the stock line, thus largely reducing the loss of flue dust. Some iron was cast in this way, using a percentage of iron ore with the dust, but the high price of pig made it more profitable to abandon the experiments with dust for a while and run entirely on ore.

Experiments along new lines are to be begun soon, however. Dust will be blown into the furnace through the tuyeres by means of a patented device, using a blast pressure of 3 to 4 lbs. Furnace operators will be interested in this experiment, for CO will not be present where the blast with its dust burden enters, and it remains to be seen whether solid carbon will affect the reduction of the dust. We take the above facts from a description of the furnace in the "Iron Trade Review."

REPORT OF SPECIAL COMMISSION OF ENGINEERS ON THE PLANS FOR THE MANHATTAN BRIDGE, NEW YORK CITY.

The new plans, submitted by Mr. Gustav Lindenthal, M. Am. Soc. C. E., Commissioner of Bridges, New York City, for the Manhattan Bridge across the East River, were described and illustrated in Engineering News of Feb. 19, 1903. Briefly described they call for a suspension bridge of 1,475 ft. span, having steel eye-bar cables carried by steel towers hinged at the bottom. Upon the presentation of these plans Mayor Low appointed a commission of engineers to report upon the following questions:

(1) Are the plans in accordance with advanced knowledge of suspension bridge designing, with a view to economy of construction, provision for temperature stresses, rigidity under concentrated loads, and resistance to wind pressure; also as regards quality of steel and its protection against corrosion?

(2) Will the strength, stability and carrying capacity of the bridge be adequate for any congestion of traffic that may occur on the railroad tracks, roadways and promenades?

(3) Will the structure, as designed, be fireproof?

(4) Do the plans permit of speedy erection of the superstructure, after the completion of the anchorages and tower foundations?

The members of the Commission appointed by Mayor Low were Messrs. Geo. S. Morison, C. C. Schneider, Henry W. Hodge, Mansfield Merriman and Theodore Cooper, Ms. Am. Soc. C.E., and they submitted a preliminary report on March 9. This report was as follows:

Having been appointed by your letter of Feb. 10, 1903, a Commission to pass upon the plans which the Commissioner of Bridges is about to submit to the Art Commission, for the Manhattan Bridge across the East River, we have the honor to submit a preliminary report covering the principal features of the design, leaving our final report till the experiments which are to be made on special steel eye-bars have been completed. This report covers everything except matters dependent on the quality of the steel, and includes all features which can be of importance to the Art Commission.

GENERAL DESCRIPTION.—The Manhattan Bridge will be a suspension bridge having a central span 1,475 ft. long between centers of towers, and two side spans of equal length, each 725 ft. long, measured from center of tower to anchorage connection. Both central and side spans are somewhat shorter than the corresponding spans of the old East River Bridge.

The general design consists of four cables, supported by steel towers or bents, each cable being a steel eye-bar chain, hanging in a vertical plane. The two center cables are 40 ft. between centers and the side cables 28 ft. between centers, making the total width 96 ft. between centers of outside cables. Each tower or bent consists of four vertical posts, one under each cable, these posts having pin bearings at the bottom, the pins being carried on metal shoes of sufficient size to distribute the weight properly over the masonry.

Although the design is a true suspension bridge, the methods adopted for stiffening against irregular loads is by the use of trusses of which the cable forms the upper member, instead of stiffening trusses at the floor level, as commonly used.

Suspended from each pair of cables is a double track, double-deck steel structure, carrying two elevated railroad tracks on the upper deck and two trolley tracks on the lower deck. The central space between the two lower decks is connected by a solid floor, which forms the highway floor. Two footways are carried in brackets, extending out from each lower deck. This arrangement gives a lower floor 126 ft. wide over all, at the center of which is a clear roadway, entirely open, 35 ft. 6 ins. wide between wheel guards, and at each side a footway, also entirely open, with a clear width of about 11 ft. The arrangement seems likely to prove satisfactory. We have no suggestions to make for its improvement.

LOADS.—The maximum congested load which could possibly be brought upon this bridge would consist of a continuous train of rapid transit cars on each of the four elevated tracks, of a continuous line of trolley cars on each of the four trolley tracks, of a crowd of heavy teams on the roadway and of a crowd of people on each footway.

The heaviest rapid transit train which may run over this bridge is that adopted by the Interborough Co. for the rapid transit subway; such a train, in which two-thirds of the cars are motor cars (corresponding to the practice of the Manhattan Ry.), with 120 passengers on each car, is estimated to have a possible weight of 1,700 lbs. per lin. ft. and an extreme actual load of 26,000 lbs. The estimated maximum weight of a continuous line of trolley cars is 1,000 lbs. per lin. ft. The estimated possible congested weight per lin. ft. on this bridge would then be as follows:

	Lbs.
Four rapid transit trains, at 1,700 lbs.	6,800
Four lines of trolley cars, at 1,000 lbs.	4,000
35.5 ft. of roadway, at 100 lbs. per sq. ft.	3,550
22 ft. of footway, at 75 lbs. per sq. ft.	1,650
	16,000

This is a possible load which could never occur unless special pains were taken to produce it. The conditions which would block the tracks with continuous lines of cars in one direction would probably prevent cars entering the bridge from the other direction. The weight on the sidewalks would correspond to about twelve people per lin. ft., or something like 35,000 people on the bridge. The congestion of the roadway would be such that teams could not move. Under these conditions we consider that one-half of this amount may be taken as a maximum working load; this would make the working load 8,000 lbs. per lin. ft., which is three times that provided in the plans of the Brooklyn Bridge, and 40% greater than that taken for the Williamsburg Bridge.

The provision of 2,000 lbs. per lin. ft. for wind pressure proposed by the Commissioner is ample.

In calculating the effect of temperature provision has been made for an extreme variation of 110°, which we consider sufficient.

We consider that the bridge should be so proportioned that with the congested load of 16,000 lbs. per lin. ft., covering the whole bridge, combined with dead load and wind pressure, no stresses would be produced anywhere reaching the elastic limit of the material or impairing the stability of the anchorage. In other words, it should not be possible for such extraordinary congested load to do any permanent injury to the bridge.

We consider that the working load of 8,000 lbs. per lin. ft. should be used in designing the main members of the structure. The congested load should be used in proportioning the hangers. The floor systems of the railroad and trolley tracks should be computed for concentrated loads of 26,000 lbs. on an axle. The floor system of the roadway should be proportioned for 100 lbs. per sq. ft., with provision for axle concentration. The floor systems of the footways should be proportioned for 100 lbs. per sq. ft. We think it best to defer our opinion as to the unit stresses which these different loads should be allowed to produce on different parts of the structure until our final report, when we shall have before us the results of the experiments already referred to. We can only say now that the loads specified and the stresses which we are likely to recommend will make no great change in the weight of the structure.

The design contains three features which, though not properly novel, are departures from the common practices with suspension bridges; they are the cables, the stiffening trusses and the metal towers, each of which may be considered by itself.

CABLES.—The use of eye-bar chains is older than the use of wire in suspension bridges. It is proposed to make these eye-bars of special steel having an elastic limit of 50,000 lbs. per sq. in., and to subject them to unit stresses about one-half those put on the wire cables of the Williamsburg Bridge. As the cables must carry their own weight, as well as that of other parts of the bridge and the moving load, their section must be somewhat more than double the section of wire cables. The quality of the steel is the only novel feature about these cables, and while the indications are that a steel will be obtained which will fully meet the requirements of the case, we ask to defer any final opinion on this subject for the present. If it should be found impracticable to get this high grade of steel, similar chains can be made of steel which is in daily use, involving an increase in size of chains, but not modifying the general features of the design. The chains have decided advantages in the accessibility of all parts for inspection and protection, as well as in economy and rapidity of erection; they are to be preferred to wire cables whenever the cost of the chains is not materially greater. The cost of eye-bar chains and wire cables in this bridge would be about the same.

STIFFENING TRUSS.—Each chain is stiffened by three trusses, one for each span, the upper members being the curved chains, the lower members being in line with the floor for about half the length of each span and inclined upward from such horizontal lines to the top of each tower. The web consisting of vertical posts, which serve also as suspenders for the floor, with diagonal tension members, the length of panels corresponding with the length of the bars in the chains. Each truss is an articulated structure the strains in which can be definitely calculated, although its peculiar outline makes these calculations more than ordinarily complicated. The great depth of the truss at the middle of each side span and at the quarters of the central span, where the tendency to disturbance is greatest, will produce a very rigid structure, the deformation being so little that the strains can be determined with all necessary accuracy without considering changes of shape. This form of stiffening truss is desirable for the greater stiffness it produces and the more positive determination of strains under all variations of loads; the eye-bar chain cables render its use possible.

TOWERS.—The tower adopted is perhaps the most novel feature in the design, but the novelty consists in its application to a structure of this magnitude. Each tower is really a bent and consists of four vertical posts, which are built steel members, each supported on a pin at the bottom, the chains being rigidly fastened to the top with pins. The four posts are connected by cross struts and bracing into a rigid frame more than 300 ft. high and 96 ft. wide between centers, which is held vertically by the chains, but is free to rock on the pin bearings below to accommodate such changes in length as may take place in these chains under strain and temperature. The design is correct in principle and secures more uniform pressures and results more closely coinciding with the calculations than may be obtained from any form of rigid tower. Wherever metal towers are used we consider that the best practice is to fasten the cables rigidly to the top of the towers, providing for changes of position by the spring of the tower rather than by movable saddles, the increased strain in the metal caused by such deflections of the towers being easily kept within safe limits. The device of a frame supported on pin bearings below eliminates even these strains.

ANCHORAGES.—The general plan of the anchorages,

as shown by the preliminary studies, seems to us satisfactory, although the permissible pressures on the foundations cannot be finally determined until the material in the bottom is exposed.

In reply to the four specific questions contained in your letter of appointment we beg to advise you that:

(1) The plans are in accordance with advanced knowledge of suspension bridge designing. They are likely to be as economical in construction as other forms of suspension bridges. They provide fully for temperature stresses. They provide for a structure of unusual rigidity under concentrated loads. Ample provision is made for wind pressure. They are consistent with the best protection from corrosion. Our report on the quality of the steel must be deferred to await the results of tests not yet made.

(2) The strength, stability and carrying capacity of the bridge will be adequate for any conjection of traffic which may occur on the railroad tracks, roadways and promenades if the provisions for loads laid down heretofore are followed.

(3 The structure as designed will be incombustible.

(4) The design favors speedy erection of the superstructure after the masonry is ready.

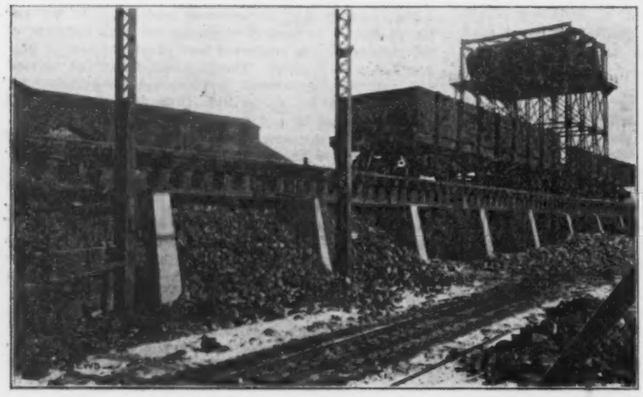


FIG. 1. VIEW OF PORTION OF COMPLETED TRESTLE IN USE.

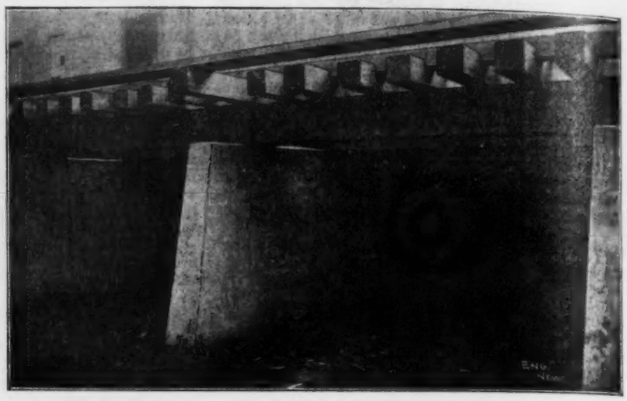


FIG. 2. A NEARER VIEW OF THE REINFORCED CONCRETE BENTS.

A RAILWAY TRESTLE WITH BENTS OF REINFORCED CONCRETE.

By Wm. A. Allen,* Assoc. M. Am. Soc. C. E.

A piece of trestle work built last fall at Perth Amboy, N. J., differs from the ordinary trestle in having its supporting bents made of concrete, reinforced with steel rods. The trestle in question runs over coal and ore stock piles, and is a comparatively low structure. The concrete bents form solid dividing walls between the different spans, and thereby make it more convenient to separate the different lots of ores and coals than if ordinary timber or steel bents were used. The abrasion of the bents by the ore is an important consideration favoring the concrete bent. The construction used is novel, and it seems to have points of merit for many cases of trestle work, especially as some materials have a decided corrosive action on iron and steel and also hasten the decay of wood.

A good view of a portion of the completed trestle is shown in the accompanying Fig. 1; a nearer view of one of the bents is given in Fig. 2. The concrete bents are simple crosswalls resting on foundation piles and carried up to the under side of the stringers. Cast-iron boxes are fastened to the top of the wall by anchor bolts set in the concrete, and the ends of the wooden stringers are notched to fit into these boxes. The trackwork above the stringers is arranged in the ordinary way, with crossties, guard stringers and a footwalk.

The details of the trestle are given in the drawing, Fig. 3. The structure is 1,277 ft. long between the extreme bents, bents being placed 12 ft. apart on centers, and rises at each end on a 3½ % grade from a low approach embankment to a normal height of 9 ft. 2 ins. to top of rail, corresponding to a height of 6 ft. 9½ ins. to top of bents. The stringers are each a double timber of two 8 × 16-in. yellow pine sticks spaced one inch apart by cast-iron separators. The cast-iron boxes in which the ends of the stringers rest, shown in Fig. 4, are anchored by 1-in. bolts set in the concrete of the bents. These boxes have the object of protecting the ends of the stringers from the weather. The stringers are anchored at both ends of the trestle, and owing to this fact, to the imbedded rods, and to the stability and weight of the concrete bents, no longitudinal bracing between bents was necessary.

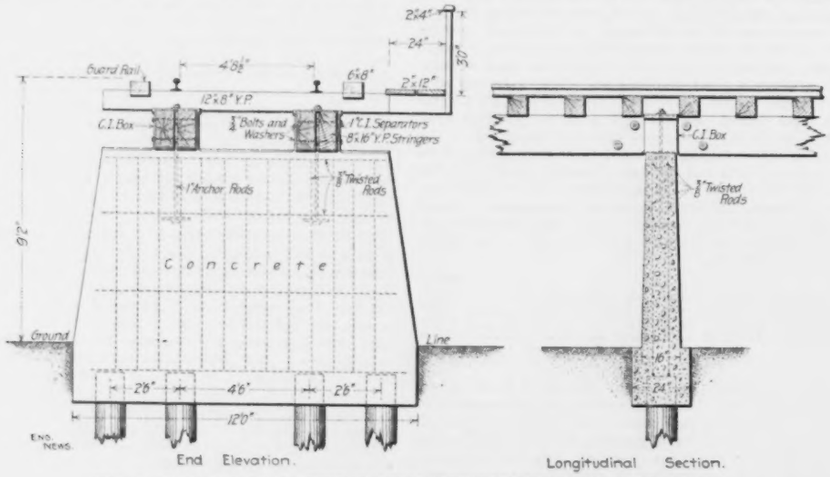


FIG. 3. DETAILS OF TRESTLE WITH REINFORCED CONCRETE BENTS.

The bents themselves are concrete walls 12 ins. thick at the top and 16 ins. at the ground level. The top of the wall is sloped both ways to shed water, except where the boxes rest on it. At the ground level each bent spreads out to form a footing 24 ins. thick, which rests over four 13-in. drawing, the vertical rods are arranged in two vertical planes 8 ins. apart in the direction of the thickness of the wall, and are set 18 ins. apart in each row, being staggered in the two rows. The object of the rods is to provide against tension in the concrete due to longitudinal traction of braked trains.

The bents were built in forms made of ⅞-in. dressed lumber, stiffened by brace pieces and bolted across at the ends. The inside faces of the forms were well soaped. The forms were allowed to remain in position about 48 hours. The concrete used in the bents was composed of 1 part Giant Portland cement, 2 parts sand and 4 parts broken slag from a lead blast furnace. It was allowed to set one month before the trestle was put into use, but in the meantime the superstructure had been placed. The ends of the stringers where they rest in the cast-iron boxes were well coated with "sludge," a tarry residue of fuel oil, and this with the protection afforded by the boxes is thought to ensure the arrest of decay.

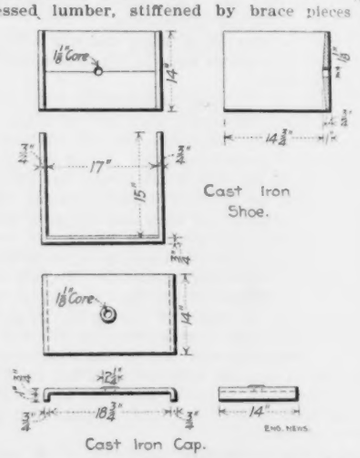


Fig. 4. Details of Cast-Iron Boxes Encasing Ends of Stringers.

The trestle was designed by and built under the supervision of the writer in September and October of the past year. The contractors were Geo. W. Rogers & Co., of New York city.

The trestle was put into use November 17, 1902, the concrete having been finished on October 17. The structure has been used continuously since then by heavy trains of loaded ore cars, and no cracks of any kind have appeared in the concrete. The cost of the concrete bents was about the same as that of equivalent wooden bents, including braces and mud sills.

*Superintendent of Construction, American Smelting & Refining Co., Perth Amboy plant, Maurer, N. J.